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INTEGRATING DEFENSE INTO THE CIVILIAN TECHNOLOGY AND INDUSTRIAL BASE

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IDA conducted research for the Defense Conversion Commission on the implications of conversion for the technology and industrial base necessary for DoD to carry out its mission of reconstituting or building back its forces in a period of six to eight years. In the post-Cold War security environment, this must be done with reduced defense budgets under circumstances in which DoD technology no longer dominates commercial technology and U.S. technology is no longer dominant. The main thesis of this study is that these circumstances require that DoD transform its approach to development and acquisition to substantially increase the use of commercial firms and commercial technologies. Obstacles to this are [1] regulatory requirements and [2] R&D practices. Federal and DoD regulatory requirements create barriers to entry from outside and prevent DoD from making the best use of commercial products and technologies. Technology development has focused on military performance with little connection to production in relationship to commercial industry. The authors propose two thrusts: [1] eliminate unnecessary regulations and product requirements, and then tailor the remainder of the regulations to minimize the burden; and [2] refocus defense research and technology both to make better use of commercial technology directly, and to make it easier and more economical to use commercial products and processes.

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PREFACE

This paper was prepared to assist the Defense Conversion Commission in preparation of its December 1992 report, *Adjusting to the Drawdown*. This paper was prepared under the task "Reconstitution and Defense Conversion" for the Office of the Assistant Secretary of Defense (Production and Logistics). The views expressed do not necessarily reflect the findings, conclusions, or recommendations of the Defense Conversion Commission, the Department of Defense, or any other Federal department or agency.

The authors would like to acknowledge the helpful input of Chris Metz of the Defense Conversion Commission (DCC) staff and of David Graham who directed the IDA work for the DCC. The reviews by Dick Nelson and Karen J. Richter of the IDA staff and by Perkins Pedrick, an outside reviewer, helped sharpen our ideas and improve the clarity of our presentation. We also are grateful for the support of Eileen Doherty for editing, and Teresa Dillard, Barbara Varvaglione, and Cori Bradford for document preparation. Residual errors remain the responsibility of the authors.

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SUMMARY

A major concern of the Defense Conversion Commission in carrying out its charter has been to assure that conversion will leave an adequate technology and industrial base to allow the DoD to carry out its missions. One of these missions is *reconstitution*, defined in a White House statement as follows: "[W]e and our allies must be able to reconstitute [build back] a credible defense faster than any potential opponent can generate an overwhelming offense." With the changed threat situation following the breakup of the Soviet Union, the time period foreseen for achieving a reconstituted force is six to eight years. This study examines how best to achieve the goal of reconstitution, given this time horizon and the new defense environment.

A. THE NEW DEFENSE ENVIRONMENT

Important changes have taken place within the DoD environment: (1) the changing political-military environment and the declining Soviet (Russian) threat removes the relatively clear focus for DoD's technical requirements and demands, and reduces the resources available to meet those demands; (2) advanced technology relevant to defense capabilities is increasingly available worldwide; (3) within the U.S., the relationship between defense and commercial sectors has changed with DoD becoming increasingly reliant on commercially-developed technology (see Table S-1 below).

These three changes—the declining threat and defense budget, the declining role of the U.S. relative to the rest of the world in manufacture and technology, and the decline in the DoD research as the primary source of new technology—all point in the same direction. If the DoD is to have available the best of technology and manufacturing capability in order to stay ahead of any potential adversaries and to be able to build back forces if that were ever necessary, then integration with the civilian sector is imperative. *The question is not whether to integrate but how to integrate for reconstitution.* A reconstitution strategy calling upon the widest possible industrial base allows for *flexibility* in assembling a defense that is responsive to the threat, reasonably affordable, and technologically up-to-date. The alternative, a readiness-retention strategy, in contrast would yield unacceptably high costs, even in low threat periods, and a defense capability that is likely to be both inappropriate and out of date.

Table S-1. The Changing Environment for Defense Technology Strategy

Environment	Yesterday	Today
Military Threat	Soviet threat drives DoD R&D (Imperative for highest technical capabilities to compensate for U.S.S.R. quantity).	Soviet threat gone—unclear focus for R&D. (Imperative for highest capabilities gives way to affordability criterion.)
U.S. in the World	U.S. leads in almost all key technologies.	U.S. technology leads dissipated—particularly in production and manufacturing.
	U.S. dominates most industrial and hi-tech markets worldwide.	U.S. position declining in industrial and hi-tech markets worldwide.
DoD/ Commercial Technology in the U.S.	DoD develops and uses advanced technology ahead of commercial sector.	Commercial sector leads in using many advanced technologies.
	Commercial sector adapts technology spin-offs from defense R&D.	DoD looks for commercial technology that can be dual-use.

B. THE THREE ELEMENTS OF AN INTEGRATION STRATEGY

We identify three elements of a Defense acquisition strategy aimed at increased integration with the private sector. The goal of this strategy is to enable DoD to draw upon the commercial production and technology base with assurance to support the build up of U.S. forces in the event that a threat to U.S. security emerges calling for a reconstituted force. The three elements of this strategy are:

- A base force scaled to meeting crisis contingencies, that is modernized and transformed progressively and that maximally integrates support and training with resources in the civil economy.
- Fundamental revamping of defense acquisition to maximally achieve industrial base integration—reforming internal DoD processes and DoD's relationships with contractors to promote integration by minimizing the need for distinct defense contracting and the distinction between defense and other products.
- Defense science and technology programs emphasizing criteria for reconstitution—affordability, producibility, rapid transition into application, and integration with commercial production.

Reconstituting a larger military force from the base force within a period of six to eight years can be done only if defense systems development and production is integrated into the civilian economy. Defense must make fundamentally greater use of commercial

products, practices, and facilities. Such an approach would not maintain a reconstitution capability by direct subsidies to maintain existing defense production capabilities, but would confine such subsidies to situations that are temporary and problems that are short-term. The reconstitution program would instead be aimed at fundamental changes in defense acquisition and research and development. This is no easy task and there are considerable barriers to its accomplishment. Therefore, DoD must explicitly establish flexibility and integration as goals, plan for them, and make them priorities in its R&D and acquisition process and management decisions. In concerning itself with reconstitution in the longer-run, the DoD needs to look beyond existing ways of doing business to fundamentally different ways of designing and building military systems.

C. RECOMMENDATIONS

The strategic concept of reconstitution requires nothing less than a major re-orientation of defense thinking and practice about what and how it develops and produces. To achieve this reorientation will require changes not only in the DoD, but also elsewhere in the Executive Branch and in the Congress—Laws, Presidential policies, and Federal regulations would have to be changed. This study presents and discusses a set of recommendations for implementing the three elements of a strategy for making reconstitution a viable aspect of Defense posture.

I. Develop the base force for flexibility and reconstitution

1. Design base force to facilitate expansion to reconstituted force—

Develop a base force which includes only those capabilities needed for crisis contingencies and takes maximum advantage of the manpower, goods and services in the economy to build up its crisis response and reconstitution capabilities.

2. Re-orient weapons system requirements process to emphasize affordability, producibility and reconstitution—

Define requirements with much greater emphasis on considerations of cost, producibility, availability and efficiency of future production for surge and reconstitution.

II. Revamp Defense acquisition to achieve industrial base integration

1. Tailor regulation—

Reduce regulations by tailoring them to the nature of the market and product; less regulation is needed as the market becomes more competitive and as the products become more predictable (less specialized and experimental).

2. Eliminate special DoD regulation—

In applying social, workplace, and environmental law and regulation treat DoD contractors the same as any other firms engaged in interstate commerce.

3. Introduce commercial buying practices—

Broaden the ability of DoD contracting officers and contract managers to judge the likely performance of contractors; remove the obligation of DoD to ensure that all potentially qualified bidders have an equal "right" to bid on contracts.

4. Continue to reduce the use of military specifications and products—

Move from military standards to commercial to increase availability of suppliers and products to DoD and where possible accept commercial products: when specialized products are needed move to performance or form, fit and function measures.

5. Minimize separate cost accounting and auditing requirements—

Contractor performance should be judged as much as possible on the price and quality of the product rather than on the ability of the contractor to satisfy DoD-specialized accounting and auditing requirements.

6. Eliminate special DoD or USG "How To Manage" requirements—

Eliminate "How To Manage" Standards that have little to do with the functionality of the product and direct the management techniques of government contractors.

7. Allow contractors to retain technical data rights—

Restrict DoD's ownership interests in technical data to those necessary for defense purposes; data rights should remain with the contractor to encourage commercial development and encourage commercial firms to conduct business with DoD.

III. Re-focus Defense Research and Development toward integrated technology and industrial base

1. Change criteria for Defense R&D—

Place emphasis on linkage of DoD's R&D to the broader technological capabilities and industrial base needed: affordable performance, flexibility and integration of production, use of commercial products and processes, dual-use technologies.

2. Focus Defense S&T programs on responsiveness, flexibility, affordability—

Redirect technology development programs away from providing the "most advanced" technology to meet the threat, toward using technology to make effective defense less costly—technology for affordability.

3. Conduct ATDs for production integration—

Advanced Technology Demonstrations (ATDs) should be used to demonstrate the ability to manufacture defense systems in commercial production facilities. These ATDs should emphasize the use of commercial components to the maximum extent.

4. **Emphasize R&D to support the integration of Defense with civil sector production—**

Give priority to research and development for improving Defense production efficiency *in concert* with U.S. industry overall. DoD should support dual-use developments in

- Engineering tools and methods such as CAD and CIM
- Flexible factories—particularly those allowing simultaneous defense-commercial production
- Enterprise integration—to reduce overhead and promote lean production
- Training and planning through simulation—"virtual" factories

5. **Focus R&D efforts on applying advanced commercial technology to defense systems—**

Formulate explicit programs to improve transfer of technology **from** commercial industry **to** DoD developments and applications.

6. **Integrate/coordinate Defense and Civilian R&D through a National Technology Strategy—**

Formulate a cooperative strategy within the national government for integrating defense R&D with the commercial base. Integration of DoD technology development into a broader national technology strategy is essential to ensure that the technologies developed by DoD can be produced efficiently within the overall U.S. economic capabilities without requiring special defense-specific production capabilities.

CHAPTER I. RECONSTITUTION AND CONVERSION

A. THE DEFENSE CONVERSION COMMISSION

The charter of the Defense Conversion Commission states that:[1]

The Commission shall review (a) the impact on the U.S. economy of the reduction of resources devoted to defense procurement and (b) the potential for strengthening or establishing Federal programs ... for appropriate cooperative ventures between the Federal Government and companies predominantly engaged in defense-related activities to assist the companies in converting to predominantly commercial activities.

A major concern of the Commission in carrying out it charter has been to assess whether the conversion will leave an adequate technology and industrial base to allow the DoD to carry out its missions. In the short run, this has caused a concern that the conversion leaves an adequate industrial capability for the next several years to support *crisis response* and *crisis recovery*. In the longer run, it will mean following policies that maintain a healthy industrial base to support *reconstitution* as well (see Table I-1).[2]

Crisis Response is dependent on the base force supplemented only by what might be available in perhaps 30 days, i.e., the warm base of operating or standby production lines for critical sustainment items, and contingency contracts for items, such as air transport, that could be made available immediately. Crisis Recovery allows for rebuilding the base force following a contingency in which forces have been lost, spare parts have been consumed, and ordnance has been expended, by replenishing resources in two to four years. This case allows for extending the warm base and contingency contracts to a wider range of items, and adds restarts of weapons whose production has been shut down relatively recently. It also might include some modernizing, e.g., replacing lost aircraft with more modern versions.

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1 D. J. Atwood, "Defense Conversion Commission," April 14, 1992.

2 The table and this discussion apply largely to non-strategic and non-nuclear forces. DoD maintains a separate "Strategic Deterrence and Defense" mission. See Dick Cheney, Secretary of Defense, *Annual Report to the President and Congress*, February 1992, p. 7.

Table I-1. Preparedness Planning Cases

Planning Case	Preparedness Task	Range of Items	Response Time	Supplier Base
Crisis response	Sustain deployment of base force	Critical sustainment items	30+ days	— Warm base — Contingency contracts
Crisis recovery	Rebuild base force	All current equipment and sustainment items	2 to 4 years	— Warm base — Contingency contracts — Restarts
Reconstitution	Expand upon base force	All new TOEs, new equipment, and sustainment items	6 to 8 years to expand	— Warm base — Contingency contracts — Restarts — U.S. (& Foreign) economic base

Reconstitution, the buildup of forces to counter a significant threat, requires a much longer time horizon, six to perhaps eight or ten years. It is defined by the President as follows: "[W]e and our allies must be able to reconstitute [build back] a credible defense faster than any potential opponent can generate an overwhelming offense." Thus, as was normal in the U.S. before World War II, the defense industrial base can be supplemented by the entire U.S. and foreign industrial, government, and academic research base.[3]

The purpose of this paper is to describe the programs and policies that will support the mission of reconstitution by generating a robust baseline force as well as the technology base and industrial base so that the nation can build up forces "faster than any potential opponent can generate an overwhelming offense." In undertaking to support the planning cases discussed above, the Commission is faced with two distinct but related questions concerning the defense industrial base:

1. Over the next few years what is the best way to spend available dollars to preserve the ability to support crisis response and crisis recovery?, and

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3 *National Security Strategy of the United States*, The White House, August 1991, p. 30.

2. In the longer run, what is the best way to transition the DoD program and its internal acquisition and related processes and its relationship to industry and the broader research community so that it can incorporate reconstitution into DoD's posture?

The first question involves a relatively limited set of issues that relate to traditional concepts of industrial preparedness and mobilization but in answering it, the foundation for addressing the second longer run question is laid. In particular, the decisions concerning the nation's posture for crisis response and crisis recovery will determine the forces and equipment being retained and retired, the military and civilian manpower pool being retained on active duty or in the Reserves, the nature of the manpower pool being discharged, retired, or laid off, the nature of the infrastructure being retained, and the ability of the civilian economy to quickly provide able people.

Having laid this foundation, the DoD will have to design its R&D programs, its weapons and its infrastructure for reconstitution, building on what it has in place. The policies and programs for being able to achieve reconstitution should not be focused on the forces needed for particular scenarios or missions. Rather, the design of force structures, of weapons systems, of infrastructure, and of personnel and manpower policies, and a new relationship between DoD and industry can all be aimed at reconstitution as a major element of strategy, i.e., at the ability to build "faster than any potential opponent." Indeed, there are many practical and inexpensive steps that can be taken to make it quicker and easier to reconstitute forces. These include employing new technologies and management approaches for developing and manufacturing weapons, designing support systems (e.g., logistics, transportation), formulating tactics, and training active and Reserve manpower and the DoD civilian labor force. Reconstitution entails a focus primarily on building flexibility into the DoD acquisition system in the long run; rather than expensive programs to retain the capabilities that are in place today.

B. POLICIES TO ACHIEVE INTEGRATION

There are three broad policy goals to implement a strategy or program appropriate for reconstitution. They cover: (1) the baseline force; (2) DoD processes and contracting relationships; and (3) the science, engineering and technology base, and the use of technology to change the nature of manufacturing. They are—

- To maintain a baseline of weapons and military systems that is effective, designed to be easily produced, and simple to use;

- To change DoD processes and policies to promote a single, largely integrated commercial and defense industrial base significantly reducing the distinction between commercial firms and defense contractors by simplifying DoD internal processes and by tailoring regulation to match the degree of uncertainty in technology and cost;
- To design and fund a DoD science and technology program that promotes a robust science, technology and engineering base and a flexible integrated commercial and defense industrial manufacturing base.

These three technology and industrial policy goals together will determine how fast and at what cost a new force can be built, and how effective that force will be.

The first policy goal is to development and deployment of a *base force of weapons and military systems and a baseline program* that is amenable to reconstitution. The description of the baseline program would include the stage of development and deployment of its major systems, ranging from the early milestones to full operational capability. A full inventory of obsolete weapons, although more useful for crises deployment, probably would be less valuable for reconstitution than would an Advanced Technology Demonstrator (ATD) of a highly effective weapon that is (1) simple and inexpensive to manufacture quickly, perhaps using commercial components, and (2) easy to learn to use, requiring skills readily available in large numbers in the civilian labor force. The acquisition strategy for weapons development would use ATDs, prototypes, planned product improvements, and other techniques to continue to develop and test improved weapons capabilities for possible incorporation in systems, either as modifications to existing systems, or when build-up is needed. Moreover, ATDs could be developed as part of a program in which flexible manufacturing is tested.

The second policy goal is revision of DoD internal processes and contracting procedures to achieve an *integrated industrial base*. The measure of whether the DoD is improving in integrating the industrial base would be the extent to which the Department finds it easier and less costly to contract with commercial firms and the extent to which commercial firms find it possible to deal with and respond to DoD needs.

The third policy goal is promotion of a *robust science, technology and engineering base and a flexible, integrated commercial and defense industrial manufacturing base*. This flexibility and integration would be reflected by the extent to which the U.S. S&T program is generating the human and physical capital and the knowledge base to generate the economic power to support a strong defense and a potential for reconstitution. It would be reflected by the extent to which the DoD S&T

program yields the variety of weapons and forces that might be needed. Here one would focus on how DoD is supporting key or critical technologies, on the abiiity to manufacture quality systems quickly (presumably using existing facilities or facilities that can be built quickly), and on fielding weapons that are effective in the field. Moreover, one would have to consider not only the DoD effort but also that of other Federal agencies, the profit and non-profit private sectors in the U.S., and the technology and manufacturing capability abroad. Finally, flexibility and integration would be reflected by the ability of the commercial manufacturing sector to produce both military and commercial systems and by the ability of manufacturers to move from one type of system to another. Manufacturing facilities would evolve from specialized assembly lines to flexible facilities that could produce a variety of commercial and military products.

C. OVERVIEW OF THIS PAPER

In order to achieve a robust reconstitution capability, it will be necessary to consider major changes in government policy in three broad areas. First, the programs that buy and operate the base force and the baseline program of the DoD should be designed for reconstitution (Chapter 2). Second, the supplier base should be expanded by tailoring regulation both with respect to DoD internal processes and with respect to DoD dealings with its contractors (Chapter 3). Third, the DoD should support a robust technology and engineering base, both through its own budget and through working with the rest of the government, and the use of technology for manufacturing flexibility and integration (Chapter 4).

CHAPTER II. DESIGNING THE BASE FORCE FOR EFFICIENCY AND RECONSTITUTION

To support the reconstitution strategy, it will be necessary to design the base force with built-in flexibility for expansion within the six- to eight-year reconstitution planning horizon.[1] This force expansion—as with earlier national military buildups from small force structures—must draw on the skills and capability of the commercial and non-profit sectors and the labor force. Any student, blue collar worker or executive who can learn a new skill, any university lab, corporation or other institution that can shift its focus, is a part of the defense industrial base for reconstitution. In considering how the base force and program can be designed to accommodate reconstitution, four elements will be discussed: (1) the base force; (2) training; (3) standby commercial products and services; and (4) managing modernization.

A. EQUIPPING, MANNING AND SUPPORTING THE BASE FORCE

The first step in managing DoD reconstitution is to develop a base force that incorporates into its manpower and equipment the technology that gives it an inherent flexibility for expansion—taking advantage of the availability of manpower, goods and services in the economy to build up its reconstitution capability. The science and technology base, development of new designs, and new training techniques all are necessary components in developing an appropriate base force.

The force itself should include only those capabilities and skills needed for crisis contingencies. This differs from the governing policy which, over the last 20 years, has attempted to integrate the Reserves so that the effective fighting force to be used in a contingency would include (after a substantial training time) a greatly expanded force.[2] It generally was recognized that the fighting capability of the reserve combat units, except for a few kinds of air units, were quite limited and constituted only a shell for a larger

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1 As noted earlier this discussion does not include the "Strategic Deterrence and Defense" mission.

2 The original total forces concept was to create a seamless "total force" including reserves and active units. For various reasons, including the inability to get reserve combat units up to a high state of readiness, this approach has not worked.

fighting force. Reconstitution looks at a much longer buildup time, perhaps six to eight years.

A reconstitution capability should draw upon the individual, organizational and other skills in both the civil non-profit and commercial sectors. This includes, but goes beyond, the increased use of commercial components and manufacturing capabilities to produce weapons. It also includes other skills and services, ranging from something as simple as the ability of most adults to drive, to the ability of universities to organize large numbers of classes of different types, to the ability of companies such as the Marriott Corporation to set up and serve meals, and finally to something as complex as the ability of firms such as Brown and Root or Bechtel to organize a large construction project. The two major categories of activities discussed below are training and standby commercial activities.

A deliberate policy of reconstitution, in which the time horizon for the buildup is six to eight years, must depend on the civil economy, not only to save money, but also because often the private sector is better able to provide the product or the service. In some areas, the DoD already goes to the commercial sector, although often as a last resort. In many others areas the DoD has been reluctant to go outside the military.

B. MANAGING MODERNIZATION

If DoD is to successfully transition from post cold war downsizing to a future defense capability that can be flexibly reconstituted, the Department no longer will be able to assume that it will complete development, production and deployment, in large numbers, of every type of major system in the force. The timing of development and the degree to which programs are brought to completion will be critical in determining the initial conditions for reconstitution. Important tradeoffs must be made among modernization investment, technology investment, hardware procurement, and current readiness. In the future, the relative emphasis should be on technology aimed at future modernization, with some sacrifice of current force modernization, hardware procurement and current readiness.

One key to reconstitution will be the initial conditions faced by the DoD at the time that the force is to be reconstituted. These conditions are defined by the following dimensions: (1) the state of technology of the systems available to be developed and deployed; (2) the age (technological as well as chronological) of the weapons and their state of maintenance, and the number and capability of the systems; and (3) the ability to

produce. This is the base upon which the DoD has to build its forces for the future. In general, higher investments in numbers of more modern equipment will come at the expense of more elaborate Advanced Technology Demonstrators (ATDs), prototypes, planned product improvements, and other programs to advance weapons technology.

The overall technology and industrial base provides the foundation for developing and producing an array of modern weapons and other military systems. The DoD requires an acquisition strategy that emphasizes advances in the state of the art without investing in unneeded development and production. This is not a strategy that produces the most effective individual weapons or provides them in the shortest time, but rather one that makes the best time-cost-technology tradeoff. To do this, it is necessary to know, as development progresses, what these tradeoffs are for the array of available weapons.

Various proposals have been made for planning for system development programs that are not carried into full scale production or that include only minimal production. These proposals have been given various names and have been combined with various levels of limited production under such phrases as virtual swords,[3] flexible acquisition,[4] rollover-plus,[5] prototyping-plus,[6] and dual-track prototyping.[7] All emphasize keeping up spending on R&D to stay at the leading edge of technology. They also are dependent on the use of simulation and other techniques to assure producibility.

Indeed, the recent DoD acquisition policy contains, as one element, the use of ATDs.[8] ATDs are to be used:[9]

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3 "Long Shadows and Virtual Swords: Managing Defense Resources In the Changing Security Environment," Ted Gold and Rich Wagner, April 1990, unpaginated.

4 *The Future of Military R&D: Towards a Flexible Acquisition Strategy*, Paul H. Richanbach et al., IDA P-2444, Institute for Defense Analyses, Alexandria VA, July 1990, pp. 15-17.

5 "Tomorrow's Defense From Today's Industrial Base: Finding the Right Resource Strategy for a New Era," Rep. Les Aspin, Chairman, House Armed Services Committee, February 12, 1992, unpaginated. Rep. Aspin proposes a program of four elements: selective upgrading, selective low-rate production, rollover-plus and silver bullet procurements.

6 *Building Future Security, Strategies for Restructuring the Defense Technology and Industrial Base*, Office of Technology Assessment, Congress of the United States, Washington, DC, June 1992, pp 12-13 and 51-75.

7 See *Holding The Edge: Maintaining the Defense Technology Base*, Office of Technology Assessment, Congress of the United States, Washington, DC, April 1989, Volume 1, pp. 11-13.

8 Don Yockey, Under Secretary of Defense for Acquisition, Memorandum on "Defense Acquisition," 20 May, 1992.

9 *Defense Science and Technology Strategy*, op. cit., p. I-16.

> ...to conduct more rigorous 'up-front' technology developments so that the acquisition cycle can be made less risky .... These demonstrations ... will range from demonstrating the military utility of new technological concepts in a laboratory environment to integrating and assessing technology in as realistic an environment as possible.

ATDs also could be used to demonstrate the capability to manufacture a missile in a plant meant for another purpose, or to adapt the military system to the plant, or to modify the plant to manufacture the system. ATDs also could be used to test the design of a flexible factory, and to feed back to simulations of production systems. Indeed, the current and proposed program of Technology for Affordability includes a whole series of demonstrations of manufacturing processes for major system components, mostly involving electronics. This approach could be extended to experiments with whole missiles, or with major subsystems of ships or aircraft, e.g., an aircraft wing or a section of a ship hull.

C. TRAINING

If the nation were to reconstitute forces beyond the turn of the century, a new generation of soldier would have to be trained. Technology must be developed to help with this task in two ways: first, the use of technology for training, including computer learning and simulation, will be needed to enable the DoD to reduce both the time required for training and the demands for training personnel. This is an area that presently is receiving a high level of attention from the military Services and this should continue.

Second, technology could be integrated in the next generation of weapons and support systems to make them easier to operate, allowing soldiers to become proficient in their use relatively quickly. The use of Stinger air defense missiles by Afghan peasants in their war against Soviet forces presented a graphic example of how a technically advanced weapon could be used effectively with a minimum of training. Thus, the design of force units, weapons, and training will be important determinants of the time required to reconstitute forces. These long-run issues deserve much more thought yet only the most far-sighted military thinkers have begun to focus on them.

D. STANDBY COMMERCIAL SERVICES FOR SUPPORT FUNCTIONS

In planning for expansion of support functions, the DoD should make use of existing commercial firms that provide services that are the same as those needed in DoD.

These can be done through standby contracts to provide commercial services. Although not a new concept, it could be greatly expanded in areas where it is already applied and extended to new areas. Types of support include telecommunications, logistics, engineering, electronics maintenance, medical support, food processing, catering, laundry, automotive and aircraft maintenance and repair, express delivery of spare parts and other supplies, and construction.

It would expand the long-standing DoD program, the Civil Reserve Air Fleet (CRAF), in which the government contracts in advance to use the commercial airlines to provide crisis-response services on a contingency basis without declaring a formal emergency. This is a contractual arrangement that gives the DoD airlift standby capacity without having to buy airplanes and train air crews. Similar arrangements in somewhat different form exist in communications. The contractual arrangement not only covers contingencies but may pay the contractor to modify its product or service in a way that it would not if it were purely commercial, e.g., the CRAF program paid airlines to add extra strength to aircraft to accommodate military cargo.

In the Desert Shield-Desert Storm Operation, for example, not only did the CRAF system operate well, but also there was also an extensive infrastructure of contractor support across a wide spectrum of military functions. The CRAF fleet transported 65 percent of all troops to Saudi Arabia and 25 percent of all airlifted cargo.[10] In addition, contractors deployed with many weapon systems, including the Patriot missile and the JSTARS aircraft, to provide maintenance, repair, training, and other functions. Many support functions for existing forces as well as reconstituted forces could similarly be provided on a contingency basis under contract to the DoD.

These functions could be provided cost-effectively on a contingency basis in the future—either for a protracted deployment of standing forces or for training and expansion of reconstituted forces. Immediate services could be contracted for in advance with first-rate commercial suppliers through a system of standby contingency contracts, essentially as is done currently through CRAF contracts.

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10 Dick Cheney, Secretary of Defense, *Annual Report to the President and the Congress*, Washington, DC: Department of Defense, February, 1992, p. 93. In addition, commercial ships hauled 68 percent of all cargo into the theater.

Expanding to these areas and to training and force expansion would require a major change in military culture. In particular, the Services would have to use civilians in areas that have traditionally used only military personnel.

CHAPTER III. REVAMPING DEFENSE ACQUISITION

A. THE DEFENSE SYSTEM ACQUISITION PROCESS

Defense acquisition comprises a broad range of distinctly different types of activities. At one extreme major systems are very expensive, acquired in small quantities, but require relatively few formal procurement actions. Major systems and their related subsystems and components are important drivers for the costs of defense procurement. At the other extreme, many DoD procurement contracts are for standard items purchased in large quantities at low cost per item. But in between are many requirements for items which are less costly and complex, but are not commercial off-the-shelf items.[1] But, under current practices, many of these items are today still acquired through elaborate procedures and specifications rather than making use of commercial practices and commercially available products.

When reviewing the defense acquisition process, it becomes apparent that there is much room for narrowing the domain where the extraordinary requirements for regulation and oversight are employed. Not only would the greater use of commercial or commercial-like processes and procedures make sense from the standpoint of reducing the costs of military systems and related subsystems and components, it also would fundamentally improve the capability to reconstitute forces. The fact that today the most extreme measures of defense oversight and auditing have flowed down to the most commercial-like acquisitions and to arenas where commercial capabilities are already highly robust demonstrates how far things have gone in the opposite direction.

This chapter first provides a perspective on the factors that drive the demand side of the defense industry. Specifically, it discusses the implications of the defense industry's non-market demand structure for the evolution of the defense procurement system. This procurement system is characterized by regulation, inflexibility, and divergence from commercial practices. From this introduction, the chapter then discusses

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[1] Gansler discusses the rationale underlying the use of detailed specifications for even such prosaic items as undershirts and fruitcake, and reviews the suggested alternatives to their use, Jacques Gansler, *Affording Defense*, Cambridge, MA: MIT Press 1989, pp. 189-195.

the impact of the highly regulated defense procurement environment on reducing commercial industry interest in pursuing defense business and the decrease in effectiveness of DoD acquisition. The regulations themselves generally are costly and not necessarily effective in achieving their intended objectives, while posing negative incentives to firms wishing to perform defense business. The chapter then presents arguments for tailoring the regulation of the defense industry based on an assessment of the characteristics of the different types of products that DoD is procuring. The key differentiating factors are the nature of the market and the degree of uncertainty regarding the product.

The chapter then discusses the potential for tailoring regulation in two broad classes—internal DoD requirements and those targeted at firms that contract with DoD. Regarding internal requirements four major areas are assessed: (1) product-related standards and specifications, (2) management related standards, (3) the DoD solicitation process, and (4) auditing and oversight. Regarding contractor activities we conclude with suggested areas to reduce regulation regarding: (1) cost accounting and financial reporting, (2) DoD imposed "how to manage" standards, (3) special defense industry environment and workplace requirements; and (4) information protection requirements.

1. General Characteristics of Defense System Demand

The defense acquisition process for military systems is driven by the requirements of the DoD for obtaining new equipment and replacing existing equipment using the research, development and production capabilities of private sector firms.[2] The requirements process is an elaborate one of linking projected threats and capabilities, existing inventories and their expected service life, and new technologies and their enhancement of performance. This operates through an iterative process of interaction between those who consider technical options and capabilities (the Services, the Joint Staff, the Unified and Specified Commands, the OSD and the R&D communities) and those who consider priorities and resources (the Service and OSD policy and management bureaucracies). Staffs arrive at plans and programs for new systems that become progressively more definite and tied to budgetary figures. Equipment development programs become authorized in progressively more concrete terms in

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2 Merton J. Peck and Frederic M. Scherer, *The Weapons Acquisition Process: An Economic Analysis*, Boston: Harvard University, 1962, p. 3, notes that this use of private businesses for weapons development is a "distinctive feature" of American weapons development and production.

response to projected needs for improved capabilities against projected threats, assessments of equipment obsolescence and replacement needs, and opportunities created by advances in technology. While the internal activities within DoD are important, so is the interaction of these with the Congressional budgetary process.

Understanding the demand aspects of the defense acquisition process is important to properly assess prospects for increased integration of the defense technical and production capabilities with that of civil and commercial industry. This is a highly structured, systematized, bureaucratized and politicized demand process. It is so structured because it is designed to meet the imperatives of an articulated strategy that is driven by a broader conception of "requirements" in terms of the capabilities that are or will be needed to meet identified or projected military threats. The process is highly imperfect, uncertain and very different from commercial demand.[3]

Thus, DoD is by definition a planned resource allocation system, not a market-driven system, and therefore the characteristics of the industry that supports it are heavily affected by non-market dynamics. Some of the key features of this are:

1. Requirements-driven demand promotes performance-focused specialization.
2. Single customer demand promotes orientation toward "unique" requirements—monopsony encourages monopoly.
3. Military requirements have evolved toward large-scale "major" systems focus to demand:

   defense leverage achieved through superior capabilities of major weapons systems;

   resource implications result in low volume production over a long period of acquisition;

   long service life requirements, due in part to the scale of the investment in the equipment, places additional demands relative to commercial systems;

   requirements for operation in extremes of condition and environment drives specialization in components and subsystems.

Attendant to these features are a high degree of uncertainty and great risk. Much of what is planned for is both technically and operationally uncertain. DoD's system

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[3] Gansler, *Affording Defense*, op. cit., pp. 143-151. Gansler discusses the weapon system acquisition process in some detail.

acquisition is technically uncertain because it often seeks advanced capabilities that are at the limits of knowledge and experience in application. It is operationally uncertain in that the plans are based on projected needs and priorities that may change radically due to changes external to the technical issues of the defined project—the threat, the technological substitutions, the resources available, etc. These combine to make defense acquisition very different from commercial and even most large-scale civil systems' development and acquisition.

2. Implications for DoD's Procurement Process

a. Major Systems R&D and Procurement

Risk and uncertainty are very high in DoD's major systems R&D, particularly for systems that are "revolutionary" developments, as opposed to more evolutionary concepts. This risk and uncertainty profoundly affects the weapon acquisition process: The uncertainties of the weapons acquisition process have prevented the development of a system of competitive markets.[4] In contrast to most commercial industry product developments, in defense systems development there is a premium on achieving next-generation capability (beyond current state-of-the-art) to meet projected requirement to out-perform known or potential adversaries. Thus:

> "Performance" becomes a key driving attribute for gauging acquisition—speed, accuracy, range, lethality, etc., versus current systems.
>
> Other criteria for differentiating and assessing systems—feasibility, producibility, affordability, etc., become secondary considerations.
>
> This emphasis on performance at the expense of other criteria encourages separation from commercial practice.

Some key features of this non-market system are:

(1) *Customer-Supplier Connectivity.* Defense systems research and development is conducted through joint customer-producer interaction where the customer specifies and closely monitors the development process. As opposed to the arms-length relationship in a market environment between the producer and the customer, in Defense systems the "customer" plays a major role in shaping the product, from its initial concept to its development and production. The process promotes highly specialized producers

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4 Ibid., p. 52.

whose fate is tightly linked to responding to and shaping the customer's specialized needs. Firms make investments (often supported or even subsidized by previous contract relationships) to fulfill niche demands that provide competitive advantage in the contract bidding process through specialization. Long-term relationships between vendors and customers in successive stages of R&D through to procurement increase barriers to entry.[5]

(2) *Winner take all outcome.* Monopoly suppliers result from negotiated procurement. When DoD determines the source for the production of a major system, usually a single contractor or contractor team is selected. While the process for selection may have been competitive amongst alternative contractors, the subsequent stream of production and even development contracts generally is very limited. "[O]nce a contractor has been selected to develop a new system or subsystem, it is in an extremely advantageous position with respect to receiving subsequent contracts to produce the system."[6]

(3) *Highly concentrated sectors.* Relatively few types of any major system are procured at any one time, so only a few firms will survive in a system or subsystem area. While barriers to entry into the defense industry are not necessarily greater than those of other manufacturing enterprises, the cost of entry are nonetheless substantial. So the DoD is often left with the dilemma of employing special measures to keep a "sufficient number of firms in business in each field of weaponry" stems largely to get around this inherent tendency toward concentration inherent in contracting for major systems and for unique military items.[7]

(4) *Cost-based reimbursement versus price.* DoD contracts for systems R&D on a cost-plus-fixed-fee basis. The target price of the contracted production is usually determined through a cost estimating process rather than through any market price

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5 Peck and Scherer, op. cit., pp. 198-221 concluded that barriers to entry in defense industry were low relative to manufacturing industry overall, and in relationship to incentives. Jacques Gansler, *The Defense Industry*, MIT Press, Cambridge, MA, 1980, describes barriers to entry and exit as as extremely high and thus greatly reducing free-market conditions (p. 46).

6 Peck and Scherer, op. cit., p. 325.

7 Ibid., pp. 374-376. The authors refer to the "hungry contractor" criterion for selecting contractors, which essentially implies that firms that were already well-positioned in the market were discriminated against in the bid review process. Some rationale for this criterion is related to prospective performance—a heavily committed contractor might give a new program inadequate attention. But, clearly other factors, not directly pertinent to the actual contract under bid, such as sustaining a mix of vendors for future bidding competition and production requirements.

mechanism. Administrative mechanisms are substituted for market mechanisms. The cost-type contracting approach introduces issues of cost accounting and cost allowability as well as mechanisms to discern whether the contracting firm is properly adhering to these. The system is intrinsically adversarial, as the incentives for the contractor of cost-based contracting are to identify and account for as much of the costs as possible, and for the government to reduce these to the maximum extent.

b. Products of non-market systems procurement: pernicious incentives and extraordinary policing

The existence of a system that is non-market driven creates requirements for oversight and intervention that entail intensive involvement in the manner in which firms conduct business. Business/government relations are governed by oversight, audit, and mechanisms for control. These are based on experience and evidence that, without such measures and approaches, the public interest would be injured by (1) a high degree of control by individual firms over entire areas of defense systems due to monopoly power; (2) firms setting the cost to the government of systems based on monopoly position; and (3) firms charging for the execution of contracts in excess of that which is reasonable or justifiable.

Non-market environments create problems enough without introducing the dangers of corruption and illicit behavior. These ambiguities, difficulties and dangers have led to the creation of layers of off-setting mechanisms to promote the public's interest in getting fair value from the contracting process. However, the regulatory requirements and strictures that have been placed on defense firms are becoming increasingly burdensome, to the point that the public interest is being injured by the very cost of doing business in such a highly regulated environment. The mechanisms for regulating defense contracting have reduced flexibility and promoted even further divergence from commercial practice and market efficiencies. This divergence has occurred in a number of areas: product-related standards and specifications, management-related standards, the DoD solicitation process, special reporting systems and the associated auditing and oversight, and the imposition of special social, environmental and workplace programs. These are discussed in detail later in this chapter.

At the same time, the differentiation between defense and commercial technology in many areas of application has lessened, raising the prospects that at least in some areas of defense production, the production of defense and commercial products might be integrated. Yet, the very means by which DoD does business is an obstacle to this. As

we consider defense technology development and production in the future national security and economic environment, it is appropriate that these be revisited.

c. Subsystems and Components

Apart from the development of major weapons systems, DoD also has promoted R&D for subsystems and components for achieving advanced capabilities to be used across new systems and for upgrading existing systems. Increasingly, subsystems and components:

- are often the heart of technological advance;
- are drivers of cost and performance; and
- require expertise and capabilities distinct from those of most system-level contractors.

As with most large-scale manufacturing industries, defense systems' firms face "make or buy" decisions regarding what parts of the system they will produce in-house, and what aspects they will obtain from other suppliers.[8] With technical complexity and a high degree of uncertainty involved in developing and producing advanced weapons, the make or buy decisions become increasingly difficult. In essence, as defense systems have increased in technical complexity, they have required a greater scope of expertise than even the largest defense integrators can economically support. This has led to a specialization of the subcontractors and suppliers who provide materials, components and subsystems to the prime contractors, who then integrate these into the overall system.[9] From the perspective of a defense system integrator, there are strong incentives to perform as much of the subsystem and component work as it can internally, and to maximize the amount of unique parts and components. Yet, from the standpoint of efficiency and cost, subcontracting is often the preferred approach.[10] There has been a trend for defense prime contractors to pursue vertical integration by acquiring subcontractors in such areas of technical specialty as avionics or electronics. Gansler

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8 Ibid., pp. 386-404.

9 See Jacques Gansler, *Defense Industry*, op. cit., Chapter 6, "Subcontractor and Parts Suppliers," for elaboration on the lower tiers of the defense industry that provide components and subsystems.

10 Gansler, Ibid., p. 136. Peck and Scherer, op. cit., discuss examples of the cost savings that can be realized by using subcontractor capabilities as opposed to the prime contractor trying to develop these.

quotes a finding of the Aerospace Industry Association that "Monopsony on the demand side 'tends to lead to vertical integration on the supply side of the market.' "[11]

However, because of the costs entailed in supporting the diversity of components and parts that would result from each new program separately developing and acquiring special advanced parts, DoD has sought to achieve greater uniformity through various mechanisms in its defense systems' contracting. Military standards and specifications are among the measures to achieve integration of more standardized and available components and subsystems into new systems and as basis for upgrading existing ones.

There are several reasons why these measures are needed:

- system vendor special development of subsystems and components adds to cost (both for acquisition and ownership) versus generic components and subsystems;
- system vendor capabilities in specialized components and subsystems can create supply lock-in for DoD unless more general availability is promoted;
- DoD sponsored or DoD conducted R&D on components and subsystems promotes firm-specific expertise and specialization in particular areas beyond that available in or of interest to system vendors;
- Standards and specifications promote a broader array of non-system specific components and subsystems. DoD has sought to develop "classes" of products that could meet specific applications requirements across different systems and not be uniquely designed for each specific application.

Thus, DoD has an interest in maintaining a broader array of suppliers of parts and components than is generally in the interest of the prime contractors, who would use special parts and components as an economic advantage. At the same time, DoD has an interest in controlling the diversity of supply—it cannot economically support the profusion of unique parts that would result from allowing complete freedom of program managers and contractors to employ whatever parts or subsystems they desired. However, the degree of control and oversight that has been passed down through the supplier chain has become a significant burden.

d. Non-Weapons System Acquisition

DoD acquires many non-weapons systems (even for military operations). For the most part, DoD non-weapons systems' requirements usually have civilian applications

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11 Gansler, op. cit.

and counterparts. When DoD seeks to procure these as commercial non-developmental items requiring relatively minor modifications for defense use, it is shifting from a procurement environment that is driven by unique aspects of military need to one in which it is tapping into the commercial market. In such markets, the seller is used to making price quotations and agreements on modifications of standardized products.

Such agreements are entered into by the customer without requiring special record keeping, signing over rights to proprietary technical data or reviewing the management system of the producer, and without sending in large numbers of on-site inspectors. All these are often part of the transaction when the federal government orders a custom-made variation of a commercial product. Laws and regulations that may be appropriate to unique technologically advanced systems developed on a cost reimbursement basis, are being applied to systems that do not require such regulation. It is this issue which will be addressed in greater detail later in sections B and C of this Chapter.

3. Impacts of Changes in Security Environment

The defense acquisition process evolved over the Cold War period when (1) the nation faced an external threat unlike anything it had experienced in the past; (2) the defense industry was just emerging as a unique industrial sector; and (3) its technologies were generally quite removed from those of commercial industry. In some important aspects, these conditions have all been significantly altered in the post-Cold War era.

1. Advent of "dual-use" technology: DoD uniqueness and specialty has declined.

Key areas of technical leverage for defense systems are the same as for commercial technologies, particularly electronics. In many areas, advances in commercial applications of electronics have outstripped those of the military. As the commercial electronics industry has thrived, the importance of special or unique capabilities of military electronics vendors has declined. In addition, certain types of military applications have transferred into civilian arena, e.g., air traffic control radar. The result is that electronics, one of the key areas of technological leverage for defense systems, has become much less technically specialized and the rationale for acquiring separate military electronics devices has been reduced. Indeed, technically it is increasingly possible to produce defense electronic components using the same production facilities, and even the same production lines, in a flexible manufacturing environment. However, DoD-specific processes and procurement approaches impair the

ability to employ advanced commercial electronics and in particular the integration of defense and civilian electronics production.

2. The "threat" driver for requiring extremely specialized (beyond state-of-the-art) capabilities is reduced relative to other characteristics: affordability, producibility, etc.

The military threat that drove the U.S. to employ requirements for future systems that were the best that could be possibly conceived—the "technological imperative"—is fundamentally different today and will be for the foreseeable future. From this perspective, the approach to defining requirements can and should be modulated by other considerations, in particular cost, producibility, and efficiency of future production (surge and reconstitution). This approach to requirements would still be performance-driven relative to the need to achieve desired military capabilities, but would be significantly different from the "performance at any cost" perspective that the existing approach to requirements setting invites.

The changed threat environment reduces the need to push advanced technologies that transform the threat environment as the central tenet of defense systems acquisition. In the Cold War confrontation with the USSR, a major objective of weapons development was to identify and field highly advanced weapons that transformed or shifted the competition to entirely new technical areas. The basis for this approach was that it created substantial advantage for the U.S. relative to the Soviet Union, given the greater technical and industrial flexibility of our system. This proved to be a correct strategy in response to that adversary. But in the security environment of today and for the foreseeable future, it is no longer the main imperative. Rather, the requirement today is generally to systematically improve capabilities relative to the generally advancing state of the art to maintain relative superiority. There is no evidence of any adversary who can achieve step-level advantage through the introduction of technology, or who has size and scope of military capabilities that these have to be offset by introduction of step-level shifts in military technologies.

3. Cost of maintaining separate production and technology bases for specialized DoD systems, and the mechanisms for this, are less justified relative to the need for lower cost production through integration with broader civil-commercial technology and the production base.

A result of the military seeking to develop technologies that are well in advance of the current state of the art is that its R&D programs are, by definition, highly uncertain, and therefore require extraordinary approaches to manage. Given a shift toward incremental improvement through systematic upgrade to meet projected military requirements, the need for such non-market approaches is reduced—or alternatively the programs can be increasingly re-balanced toward commercial practices and the use of commercial facilities and components. Moreover, the cost of not shifting to such commercial and commercial-like practices to maintain even a highly reduced base force would be excessive, relative to both budgetary constraints and the prudent use of resources.

4. There is need to revamp the process of military acquisition to reduce separateness and increase integration with civil-commercial process.

The changed environment profoundly affects the entire rationale and operation of defense systems acquisition. The system was optimized to produce exactly what it did—the very best advanced weapons systems that were technically feasible. The mechanisms that drove this system were themselves designed to control and oversee the process of first developing such extremely advanced systems and then determining their production. Linkage of these to any existing industrial capabilities, or any consideration of resource constraints, was tangential. The concept of a defense strategy based on a base force and the ability to reconstitute a larger production capability produces very different requirements for conceiving and then developing and producing defense systems. Reconstitution places an imperative on being able to engage the industrial production capabilities of the economy as a whole efficiently. The primary consideration for designing next generation systems under this concept should be— "Can we build them when we need them?" This refocuses the weapons systems development process on its integration with the nation's future industrial capability. Without such integration, reconstitution in the long-term will be impossible.

One measure of the efficacy of a reconstitution strategy will be its ability to build up a large modern military force in the desired time using the then existing commercial economy. This buildup will require that the DoD stay as close as possible to the commercial world rather than create a specialized market, with a requirement that firms develop specialized knowledge and skills just to do business with the DoD. Ideally, the specialized knowledge to operate with the DoD should not be any greater than that required to do business with any large commercial customer.

To do this, it is not enough that the DoD have available a plan that allows, during a reconstitution emergency, for waivers of most residual requirements that limit the flexibility of the DoD to contract with commercial firms. DoD needs to transition to a new supplier base—one that is integrated into the U.S. commercial industrial base. There are a number of ways that the DoD can act to expand its use of commercial suppliers and to make DoD supplies and commercial supplies one in the same.

There are a number of regulatory barriers that in the past have served to limit the ability of the DoD to buy from commercial firms and the ability of commercial firms to sell to the DoD. These factors have been reviewed many times in the past, going back to the Hoover Commission in the 1950s. Like all arguments on regulation and deregulation, there will be arguments for keeping the existing structure, and tradeoffs to be made if the present structure is dismantled. However, the introduction of reconstitution as a significant element of strategy now weighs an additional factor on the side of deregulation.

The ways in which the defense market can be deregulated and the supplier base can be expanded involve the following: changes in and increased flexibility with respect to requirements, particularly military specifications; the relaxation of specialized "management requirements;" and the relaxation of specialized social programs. The next section reviews DoD regulatory processes and outlines a framework for tailoring regulation to product characteristics. Tailored regulation will open a much wider range of DoD products to commercial style competition and business practices, thus removing some of the important barriers to an integrated DoD-commercial base.

4. The Conflicting Purposes of the DoD Acquisition System

Although the ultimate purpose of the DoD's acquisition of weapons and materiel is to protect the national security, that purpose contains within it many conflicting purposes. These conflicts may arise out of differing views of what constitutes national security, but they also may arise out of attempts to use the DoD acquisition system for purposes other than national security.[12] The list of purposes includes items, such as

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12 The Office of Technology Assessment in a recent report lists the following 14 purposes of laws enacted by the Congress "to curb abuses and to foster goals other than efficient procurement of defense equipment: (1) civilian control over military procurement; (2) administrative control over Service Activities; (3) Congressional control; (4) protection of Congressional constituent interests; (5) environmental protection; (6) fairness; (7) competition; (8) accountability; (9) honesty; (10) controllable business practices; (11) minority interests; (12) small business interests; (13) protection

"competition," that are meant to promote efficient procurement. However, the laws, their implementing regulations, and interpretations by inspectors, auditors and the courts have imposed restrictions on the DoD that do not promote efficiency and indeed are inconsistent with efficient practices of commercial industry. Many of the specialized government or DoD regulations that are meant to accomplish other purposes, unrelated to efficiency or national security, are in fact not needed to meet those purposes and may even be counterproductive in terms of efficiency and national security.

A tailoring of the application of DoD's rules and regulations to fit the nature of the product could increase integration and flexibility without undermining the integrity of the acquisition system. One way to expand the supplier base is to eliminate special regulation for defense firms beyond that required for normally operating within the economy. The special regulatory regime now governing the defense market has several broad purposes related to efficiency: to specify special requirements that narrow the information needed to select the best product; to determine what the "real" cost of an item is; and to determine what the "real" cost should be. Finally, there are regulations related to the broader purposes of government, including a presumed right of all qualified bidders to bid on a contract.

There is a strong case to be made for tailoring regulation and for curtailing special DoD regulation independent of considerations of reconstitution. But reconstitution makes this tailoring a necessity because DoD will find it necessary to depend to a greater extent on the civil economy. Reconstitution will require the participation of firms that do most of their business with commercial firms, domestic and foreign, and with the general public, rather than being mainly suppliers of the DoD. The DoD is already dependent on the commercial economy for much of its technology, since most advanced technology is dual-use. If firms that are oriented toward defense are to survive and prosper, they must be able to apply their technologies to the domestic economies, not only to make the profits they need to stay in business, but also to keep up with the latest in technology.

In considering how to tailor regulation, it is necessary to understand the underlying goals of the regulation. Since the regulatory framework is very broad, at least three facets must be considered: technologies, products and contractors. Each of these

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against conflicts of interest, and (14) prevention of large profits at taxpayer expense." *See Holding The Edge*, op. cit., Volume 1, p. 10.

presents different problems, but all the problems are related to concerns about the fairness of the transaction.[13]

First, concerning technologies, there was fear that the U.S. government was paying twice for technology, that foreign governments were unfairly benefiting from research paid for by the U.S. government, and that contractors were unfairly commercializing technology that was paid for by the government. This led to DoD criteria that technical data packages for research that was jointly paid for by the contractor and DoD be turned over to the DoD for use by others outside the Government, and that the contractor account in great detail for who funded which parts of the research and technical data. This in turn requires detailed and often arbitrary cost allocation for research and development, with some risk that commercial property will be claimed by the government. Such requirements discourage the commercial use of DoD-developed research; it also discourages the contractor from risking his own commercial technology in a DoD product.

Second, there is concern that the DoD pay no more than a fair price. Much DoD regulation and the cost accounting standards are largely introduced to guarantee that the government does not pay more than it should. The use of detailed cost accounting rather than market research and other methods of estimating the fair price creates an illusion of accuracy and fairness in what are arbitrary rules and allocations. In many cases, existing regulations could be replaced with improved market analysis. Even custom made products, if they are variants of more commonly bought products, can be compared to the prices and characteristics of those more common items. This market analysis, combined where appropriate with statistical cost analysis, is used by appraisers, whether for estimating the value of a building, a business, a private home or an art object. Thus, for products, the variable one should be concerned with is the degree to which comparable products are available for comparison, whether in an impersonal market or through arms-length transactions. The better the quality of the more easily available information, the less effort will be required to price the item. But "cost accounting standards" have hardly been a solution to the problem of evaluating the contractor's accounting system. The burden may have shifted from the contracting officer to the auditors from DSAA, the Inspector General, and the GAO, but the need for information has not been lessened. We

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[13] See Frederic M. Scherer, *The Weapons Acquisition Process: Economic Incentives*, Division of Research, Graduate School of Business Administration, Harvard University, Boston, MA, 1964.

believe that regulation is necessary only in cases where the market does not reveal what prices are reasonable.

The third concern about the contractor and cost reimbursement relates to the R&D and production of systems that involve some cost reimbursement. The DoD has promulgated regulations that try to assure that a contractor must and can be kept from shifting costs from commercial items or DoD fixed-priced items to DoD cost reimbursement contracts. Again, the burden of such regulations and reporting systems falls ultimately on both the DoD and the contractor, with the contractor finding it necessary either to operate separate divisions for DoD and commercial, or to spread the cost of the added overhead to his commercial operation. This added cost is a major deterrent to selling to DoD. It entails costs which the firm can only recover from the DoD, and then only if the relationship continues for a sufficient length of time.[14]

Once chosen, the DoD contractor is constrained by an incentive and regulatory system governing pricing and cost accounting (Cost Accounting Standards), detailed product specifications, material management systems, technical data rights, and how to manage standards. In all of these, the contractor is subject to criminal penalties for activities that might have been subject to civil rather than criminal penalties in the past. During the 1980s, there was increased use of criminal statutes to enforce government interpretation of the contracting laws. Mis-statements of fact, even those that seem innocent and result in no loss to the government, are being prosecuted as if there was criminal intent.[15] These may include activities over which the contractor has no direct control and they may even include activities in which the contractor has made the government better off by not following the rules to the letter, e.g., substituting a more reliable part than was promised.[16]

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14 See for example, *Holding the Edge*, op. cit., Volume 2, pp. 110-113.

15 The fraud statute, 18 USC 1001, states that

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

Similar wording is contained in 18 USC 286-287 involving "false claims" against the United States Government. Also relevant is 18 USC 371 covering "Conspiracy to commit offense or to defraud United States."

16 See C. Stanley Dees, "The 'New Morality' Environments in Government Contracts," *National Contract Management Journal*, Winter 1987, pp. 1-14. Dees quotes as follows from the DoD Inspector General's "Indicators of Fraud in Department of Defense Procurement," "...even if the item is as good,

A major purpose of the regulatory system is (or should be) to assure that the contractor is not exploiting a monopoly or near monopoly. Even in a monopoly situation, the first choice before regulation is the use of a fixed-price contract. Where such contracts are to purchase standard products sold in the commercial market, government procurement should differ little from the private sector. There is no need for special regulation concerning costs. In situations where there is a market for identical products or close substitutes, monopoly power is not a problem.

Most attempts to control the contractor and limit his ability to exploit his monopoly power have been through regulation, but there are alternatives that normally are available to the DoD. In particular, it is important to maintain a system in which the contractor's monopoly power is always threatened by substitutes of some kind. E.g., are there strategies or tactics that would be more efficient?, are there other weapons or modifications that would be more efficient? These must be considered as alternative substitutes for the market where none exist.

However, for many types of purchases such standard products do not exist. The next choice is the use of fixed-price contracts arrived at through arm's length bargaining. One reason for regulation is that such fixed-price contracts are difficult to draw up in situations where there is a great deal of uncertainty. Development contracts for major systems, construction contracts, and contracts to overhaul or do major maintenance on ships and aircraft all involve major uncertainty, although each may be of a different type. Regulation, including the use of cost accounting standards, which purport to provide a measure of costs, is seen as a substitute for both the market that does not exist and for arms length bargaining on a fixed-price contract.[17]

The regulations relate to both sides—the contractor and the DoD—as well as to the product. That is, not only does the DoD regulate the contractors, but the DoD itself is regulated. DoD is open to investigation oversight and even criminal prosecution both internally within DoD by auditors, Inspector General Offices, and criminal investigative services, and externally by the General Accounting Office and various committees of the

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there is harm to the integrity in the competitive procurement system which is based on all competitors offering to furnish the item precisely described in the specifications."

17 See Douglas P. Beighle, "Defense Contractors - The Next Spotted Owl?," *NCMA Journal*, Volume 24, Issue 1, Summer, 1990, pp. 23-24. For a more detailed discussion of the problems with fixed price contracts, including a summary of the evidence, see Jacques S. Gansler, *Affording Defense*, op. cit., pp. 165-168.

Congress. Thus there are two layers of regulation that must be examined and tailored: namely, (1) the internal system that governs regulation, oversight, and investigation of how the DoD manages its acquisition process, how it solicits and accepts bids for weapons systems; and (2) the external system that relates to regulating to the product and the contractor.

5. Tailoring Regulation to the Product

Many of DoD's acquisition regulations are conflicting and counterproductive. Even when these controls are similar to those enforced in society at large, they are different enough that special reporting systems are necessary; even the criminal law is at times introduced into what are otherwise civil matters. Thus, they put extraordinary burdens on firms that mainly service the military, and raise barriers to commercial firms that may have products that the DoD can use. Since each regulation serves some important goal, it is important to examine the conditions under which regulation is needed to serve that goal, and those conditions when the market or some non-DoD regulatory regime may serve the purpose better. We examine how regulation applies to four types of products, based on nature of the contract arrangements under which they are bought and the degree of technological and cost uncertainty (see Table III-1).

The four product classes are:

- Developments of major, technologically uncertain systems.
- Major modifications of existing military or other non-standard systems.
- Purchases of non-standard commercial products (e.g., construction project) or services, or customization of a standard commercial product (e.g., computer).
- Generic or standard commercial products.

These four types of products differ in two important aspects: the nature of the market and the degree of uncertainty. Developments of major new systems operate in a market that becomes a monopoly once the initial full-scale development contract is signed. Normally there will be few substitutes for the system once it is under way. In addition, the cost and technology of these systems typically are highly uncertain, preventing the DoD from entering into fixed-price contracts. These systems, by their nature, often lack a database of comparable systems to allow for estimating the costs and schedules. Such uncertainty, and the monopoly position of the seller once the development begins, puts DoD in a situation in which it lacks alternatives if the system

runs into trouble. All of these conditions force the DoD to exercise considerable oversight as the system is developed and produced.

Turning to the second case, as the system moves into production or when a major modification is undertaken, the buyer-seller conditions change. Such systems have a similar problem of dealing with a monopoly seller, but they have considerably less technological and cost uncertainty, are more likely to have good substitutes (e.g., the existing system, another similar type of existing system, or an upgrade of a similar system), and will have a database of earlier production and/or the development costs of the original system. The database also may include similar modifications of other systems. The reduced uncertainty and better database allow the DoD to price such systems and to enter into negotiated agreements that should require considerably less oversight than does development of a major new system.

Table III-1. Tailored Regulations by Type of Product

Category	New Development	Major Modification	Customized Version of Standard Product	Generic or Standard Product
Description	Development of major new military or other unique system	Major modification of existing military or other non-standard major system or production of major already development system	Customized modification of standard product or product such as construction only produced as custom product	Standard product available from catalog or in highly competitive market
Examples	B-2, F-22, Seawolf submarine	M-1 upgrade, F-15E	Any new military construction project, militarized version of commercial vehicle, militarized version of standard commercial computer, clothing	Off-the-shelf computer, light bulbs, standard software, automobiles
Nature of market	Normally negotiated contract, even when competition existed initially. Option is to cancel system and start over but essentially a monopoly.	Monopoly, single seller with unique product but similar to existing product or products. Negotiated contract.	Competitive with many contractors but unique product	Competitive
Degree of uncertainty	Uncertain relationship of technology, cost, capability	Moderate uncertainty but ability to start from known base and to predict based on analogy and comparison to similar products and changes	Moderate uncertainty but ability to compare and get prices on many similar products	Known standard product

Table III-1. Tailored Regulations by Type of Product (Continued)

DoD Processes				
Category	New Development	Major Modification	Customized Version of Standard Product	Generic or Standard Product
Acquisition milestone reviews	Reviews needed to resolve uncertainties at each milestone	Reduced number of reviews because of reduced uncertainty. Process generally tailored based on nature of system and cost.	Reviews tailored rather than using DoD stylized process	Not relevant or necessary
Requirements process and generation of product related specifications	Contract should encourage components to be satisfied by existing standards or variants. Shouldn't require differentiation DoD requirement from commercial product unless worth the cost.	Contract should encourage components to be satisfied by existing standards or variants. Should not require differentiation DoD requirement from commercial product unless worth the costs.	Should be based on commercial standards and specifications or on standard company product. Should not differentiate DoD requirement from commercial product unless worth cost. Differentiation should not require major increase in oversight	Based on commercial standards and specifications or is a standard company product. Not required if products are sold in a way generally available to the public, even if producers have some product differentiation.
Formulation of management related standards	Advocates & overseers of management-related standards should concentrate on these systems but regulations & standards should give flexibility to PM and contractor	Advocates and overseers of management related standards should have minimal connection with these programs	Advocates and overseers of management related standards should have no connection with these programs which can be overseen as commercial product	Normally do not apply to these products
Solicitation	Only selected contractors capable, but prime contractors must follow complex procedures to ensure "fairness"	Generally limited to existing or original developer so contract is negotiated	Under existing rules, no matter how competitive, this approach is not considered to be "price" competitive	Done competitively, but must be reopened if new product is offered which does not respond to the RFP
Auditing and oversight	Part of necessary process to resolve technical, cost, and capability uncertainties in order to product U.S. government interest	Less necessary, easier to inspect product directly, more proxy measures of cost available. Management responsibility can be left entirely to contractor. Contractor failure less of a problem to DoD.	Generally not necessary except to inspect or test product directly	Generally not necessary except to inspect or test product directly.

Table III-1. Tailored Regulations by Type of Product (Continued)

Contractor Activities				
Category	New Development	Major Modification	Customized Version of Standard Product	Generic or Standard Product
Cost accounting	Need some method of determining costs for a cost reimbursement contract. Fixed price contracts have failed in the past.	Prices can be compared to existing system and modifications can be compared with other modifications. Value of system can be compared with cost and value of substitutes.	Prices can be compared to similar projects and products	Prices available in catalogues and markets
"How to manage" standards	Need some method of resolving management difficulties if things go wrong, but some tailoring possible	Management related standards have only limited applicability to systems that are more predictable and where there are alternative sources. Contractor should be responsible for management.	Should be waved entirely. No problem of monopoly and sufficient evidence of competence should be available from other production.	Management oversight irrelevant. Product can be examined directly.
Technical data rights	Foregoing DoD interest will encourage dual-use. Retaining rights for commercial or other use requires detailed, but arbitrary split of costs of particular technology development.	Foregoing DoD interest will encourage dual-use. Retaining rights for commercial or other use requires detailed, but arbitrary split of costs of particular technology development. Firm may be reluctant to contribute its own technology.	Foregoing DoD interest will encourage dual-use & will remove impediment to commercial firm working for DoD. Likely to be asking commercial firm to jeopardize its rights to its own technology if DoD contributes even a small amount to improvement.	Not an issue. All rights belong to commercial firm.

Table III-1. Tailored Regulations by Type of Product (Concluded)

Contractor Activities				
Category	New Development	Major Modification	Customized Version of Standard Product	Generic or Standard Product
Product related specifications	Contract should encourage components using existing standards or variants, or by an existing military system or variant thereof. Such products should be broken out and evaluated and overseen as "modification," "custom," or "generic" products would be.	Contract should encourage components using existing standards or variants or by an existing military system or variant thereof. Such products should be broken out and evaluated and overseen as "custom," or "generic" products would be.	These are variants on commercial standards and specifications or on standard company products and require limited oversight similar to generic or standard product	Based on commercial standards and specifications or is a standard company product. Not be required if products are sold in a way that is generally available to the public, even if producers have some product differentiation.
Social, environmental and workplace programs	DoD contractor should be treated same as for any private company, with same laws, regulations, and enforcement mechanisms.	DoD contractor should be treated same as for any private company, with same laws, regulations, and enforcement mechanisms.	DoD contractor should be treated same as for any private company, with same laws, regulations, and enforcement mechanisms.	Not relevant. Enforcement now normally through non-DoD mechanisms.

Customized versions of commercial products are likely to have many more substitutes, with a large database of prices paid by buyers for other customized versions of the products. In many cases, databases will exist for similar products including similar customizing of other products. Competition is likely to exist for most of these products. There may be moderate uncertainty, but the DoD will still be able to make comparisons and arrive at reasonable prices. There should be relatively little need to oversee the management of such products any more than a commercial buyer might.

Finally, generic or standard products will have little uncertainty about the product, a large database of prices paid, and a highly competitive market. There will be little to do other than test or sample products to be sure that the product promised is delivered and that it meets the promised standards. Even such sampling can be held to minimum.

None of these four types of products—major technologically uncertain systems, major modifications of existing military or other non-standard systems, purchases of non-standard commercial products or services or customization of a standard commercial product, generic or standard commercial products—requires that the DoD retain technical

data rights for commercial exploitation and none requires that the DoD impose special social, environmental, or workplace constraints. The issue of data rights involves the issue of whether the DoD and the U.S. government wishes to encourage or discourage commercial development of DoD-sponsored work and, if not, how much trouble and expense it is willing to undergo in order to discourage it. In the other cases—social, environmental, or workplace regulation—these are regulations that generally apply to any firm engaged in interstate commerce, and consideration should be given to applying uniform regulations to all firms engaged in interstate commerce, whether or not they are a DoD contractor.

The following sections review how regulation could be tailored for two broad categories:

- DoD Internal Processes
  - — Formulation of Product Related Standards and Specifications
  - — Formulation of Management Related Standards by Sponsors and Advocates
  - — The DoD Solicitation Process
  - — Auditing and Oversight
- Contractor Activities
  - — Cost Accounting Standards and Other Cost and Financial Reporting Systems and their Certification
  - — "How to Manage" Standards
  - — Programs with Social, Environmental, and Workplace Goals
  - — Export Controls, Information Protection & Foreign Suppliers

B. DOD INTERNAL PROCESSES[18]

The existing acquisition directives govern how DoD will conduct its business. In some cases, such as the milestone review process, the regulations are tailored to reflect product characteristics. In other areas, such as the solicitation process and audits, there remains substantial room for improvement. The potential for tailoring regulation in five major areas is discussed below.

1. Formulation of Product Related Standards and Specifications

Many DoD systems and components are built to standards—some military, some government, and some commercial. Standards are set by single offices and by many commercial and industrial organizations. These standards allow customers to narrow the uncertainty with respect to products, reliability, environment, interoperability, documentation and other product characteristics and qualities. The existence of standards and specifications allows the purchaser representing the DoD or one of its contractors to narrow the area of judgment for a product.

The military does not know where its equipment will be needed, nor when the war will occur. Thus the military tends to be more demanding in its specifications than does its commercial equivalent. Moreover, lack of adherence to military specifications may save money up front, but in the long run may have higher life cycle costs because of increased logistics support and configuration management for components not already in the military logistics system.[19] Thus, as one departs from a standard, one must consider

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18 The problems discussed in this and the next section have been documented in a number of studies. The most recent include support work for the Advisory Panel on Streamlining and Codifying Acquisition Laws, Defense Systems Management College (also known as the Section 800 Panel). See "Government-Industry Panel Takes Far-Reaching Look at Acquisition Laws," *Inside the Pentagon*, December 3, 1992, p. 13; *Integrating Commercial and Military Technologies for National Strength: An Agenga for Change*, Center for Strategic and International Studies, Washington, D.C. March 1991; *Building Future Security: Strategies for Restructuring the Defense Technology and Industrial Base*, Office of Technology Assessment, OTA-ISC 5301, Washington, D.C. June 1992; and *Holding the Edge: Maintaining the Defense Technology Base*, Office of Technology Assessment, Washington, D.C. April 1989. See also, *A Preliminary Perspective on Regulatory Activities and Effects in Weapons Acquisition*, by G. K. Smith, J. A. Drezner, W. C. Martel, J. J. Milanese, W. Mooz, and E. C. River, R-3578-ACQ, The Rand Corporation, Santa Monica, CA., March 1988.

19 For a discussion of the current DoD position on the elimination of specialized DoD standards, see "Statement of Gregory Saunders, Deputy Director, Manufacturing Modernization, Office of the Assistant Secretary of Defense (Production and Logistics)," Before the Subcommittee on Investigations, House Armed Services Committee, July 22, 1992. Cf. p. 7 for a discussion of design and performance requirements.

the added logistics support for spare parts with its concomitant added life cycle costs, as well as the more complex configuration management problems.

Another and less straight forward reason for adhering to standards involves the added risk for the responsible DoD official if the alternative to the specification or standard fails for some reason.[20] The added cost, or loss of reliability or safety that occurs because of adherence to a standard is not obvious. On the other hand, departure from detailed standards and specifications risks blame for failure. This asymmetry, which does not reward successful innovation but punishes unsuccessful innovation, biases the system against innovation. With respect to reconstitution, it will be particularly important to know the technology and the market in order to overcome this bias.

Although this is an important issue, the problems in the DoD should not be exaggerated. Any large complex project will have thousands of components or parts, not all of which are likely to require in-depth analysis. Commercial airplanes and airliners have the same problem as do DoD systems. For example, one commercial jet engine used extensive numbers of DoD specifications and standards: 17 percent of the total number of 624 specifications and standards (see Table III-2).

Table III-2. Specifications and Standards in Selected Weapons and Commercial Systems

	Tactical Fighter		Wide-Body Airliner		Maritime Patrol Plane		Commercial Jet Engine	
Type of Standard	No.	%	No.	%	No.	%	No.	%
DoD	1100	56.1	419	20.2	713	33.9	107	17.1
NAS	200	10.2	122	5.9	192	9.1	—	0.0
SAE	50	2.5	86	4.1	55	2.6	32	5.1
ASTM	10	0.5	120	5.8	90	4.3	2	0.3
Misc. Standard	—	0.0	376	18.1	285	13.6	297	47.6
Non-Standard	600	30.6	956	46.0	767	36.5	186	29.8
Total	1960	100.0	2079	100.0	2102	100.0	624	100.0

Source: "Testimony" presented by Stanley Siegel, Vice President, Technical and Operations, Aerospace Industries Association of America, Inc., before the House Armed Services Committee, Subcommittee on Investigations, July 22, 1992, Attachment (Figure 4).

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20 For a discussion of problems in acquisition career management, see "Careers in Acquisition Management," Chapter 5, *The Defense Management Challenge: Weapons Acquisition*, by J. Ronald Fox with James L. Field, Harvard Business School Press, Boston, MA, 1988.

One way to increase the availability of suppliers and products to the DoD is to move from specialized military standards to commercial or non-government standards wherever possible, or where standards are overly restrictive, to accept commercial "off the shelf" or catalog products, moving from input-oriented specifications to performance or form, fit and function measures. In the last ten years, the number of non-government standards and commercial item descriptions adopted by DoD has gone from about 4,000 to 10,000 and the number of military specifications and standards have fallen from 33,800 to 31,100.[21] In addition to moving away from specifications and standards to performance-oriented measures, the DoD can make use of "off the shelf" commercial items sold from catalogues. These might be end items or products, and they might be components that are contained in major electronic or C^3 systems or in specialized weapons systems.

2. Formulation of Internal DoD Directives and Management Related Standards by Sponsors and Advocates

There are in the DoD advocates for all sorts of good things from competition to testing to value engineering. Some of them play roles in formulating directives that govern the behavior of the DoD itself and its bureaucracy, while others govern the behavior of contractors; some attempt to govern both. These advocates generally have an official role as advisors, but frequently they retain veto power over internal DoD processes, such as milestone reviews, solicitation of bids and other processes.[22] Moreover, they may be involved in review of contractors' activities and they may set standards that program managers and contractors alike are expected to meet when undergoing audits.[23] These "How to Manage" Standards[24] include: manufacturing

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21 Statement of Gregory Saunders, op. cit., July 22, 1992, pp. 4-5. See also, William J. Perry, "Changing the Defense Industry," letter in *Issues in Science and Technology*, Summer 1992, pp. 10-11.

22 See the Packard Commission report. *A Quest for Excellence*, Report of the President's Blue Ribbon Commission on Defense Management, U.S. Government Printing Office, June 1986, pp. 46-47.

23 The review that led to consolidation of the directives governing the acquisition process resulted in the elimination of more than 50 directives, but almost all were incorporated in the new Department of Defense Instruction 5000.2, "Defense Acquisition Management Policies and Procedures." Thus there was not necessarily a simplification of the process, but rather a consolidation of paper. See Department of Defense Instruction 5000.2 "Defense Acquisition Management Policies and Procedures," February 23, 1991.

24 For a general discussion of the problem see "Testimony" Presented by Stanley Siegel, Vice President, Technical and Operations, Aerospace Industries Association of America, Inc., before the House Armed Services Committee, Subcommittee on Investigations, July 22, 1992, p. 4. The list is only a partial one taken from Department of Defense Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," February 23, 1991, see especially, Part 6, "Engineering and Manufacturing."

management;[25] producibility;[26] quality;[27] reliability;[28] software engineering practices;[29] subcontract management;[30] systems engineering management;[31] system safety engineering; value engineering;[32] and work measurement.[33]

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25 "Manufacturing Management Program," Military Standard MIL-STD-1528A (USAF), 9 September 1986.

26 See "An Innovative Producibility Strategy," by Dr. Robert E. Schrafik and Mr. Greg Stottlemyer, *Program Manager*, January-February 1992, pp. 2-9.

27 "Quality Program Requirements," Military Specification MIL-Q-9858A, 16 December 1963, with amendments of 7 August 1981 and 8 March 1985, and "Inspection Systems Requirements," MIL-I-45208A.

28 "Reliability Program for Systems and Equipment," Military Standard MIL-STD-785.

29 For a discussion of the problems of managing software in the DoD environment see, "Case Study: The Software Industry," Appendix F, *Holding the Edge, Maintaining the Defense Technology Base*, op. cit., Volume 2: Appendices, January 1990, especially pp. 108-109. See also "Defense System Software Development," Military Standard DoD-STD-2167*A*, and "Defense System Software Development," Military Standard DoD-STD-2167a, 29 February 1988. An extensive discussion of the problems with this standard and the differences between commercial and DoD software development is presented in "Case Study: The Software Industry," op. cit., pp. 105–109.

30 "Subcontract Management: A Key Function in Acquisition Process," by Earl V. Mooney, Jr., *Program Manager*, July-August 1991, pp. 12-16. This article for program managers suggested that increased dependence on subcontracting has increased the need for government involvement in subcontracting management. It notes that the government "has no contractual means for directly monitoring problems at the contractor's plant." This leads the author to say that we have too little management direction from government: "The consensus among most government acquisition managers and their critics is that the government must be involved in subcontracting management and that the present level of involvement is inadequate. ... The MIL-STD-1528A, *Manufacturing Management Program*, prescribes that the contractor's procedures to provide continuous management visibility and control of subcontractors, vendors and suppliers shall assure that the requirements of the military standard flow down and are effectively implemented. The military standard states that "these procedures shall specify contractor review of subcontractor manufacturing management plans, systems and production facilities...Routine use of contractor manufacturing organization specialized disciplines and management of subcontractors, vendors, and suppliers is necessary to perform this requirement. Government representatives may attend these reviews as observers."

31 A recent discussion of concurrent engineering by Jerome Lake lists five of the recent approaches to "improving systems engineering practice." The author says "Some solutions offered include Willoughby Templates for transitioning from development to production (1985), Acquisition Streamlining (1986), Total Quality Management (1988), Concurrent Engineering (1988), Integrated Product Development - and Air Force replacement concept for concurrent engineering (1990)." The author, an advocate of concurrent engineering, believes that concurrent engineering is the best approach, "incorporating the best in all proffered solutions." The discussion however underscores the difficulty of the DoD telling its contractors how to manage. Jerome G. Lake, "Concurrent Engineering: A New Initiative, Can it Solve DoD Acquisition Problems?," *Program Manager*, September-October 1991, pp.18-25, especially p. 19. See also "Systems Engineering," Military Standard, MIL-STD-499B(USAF), 15 May 1991 (Pre-Coordination Draft).

32 "Value Engineering Program Requirements," Military Standard MIL-STD-1771, 30 December 1991.

33 "Work Measurement," Military Standard MIL-STD-1567A, 11 March 1983.

3. The DoD Solicitation Process

The Request for Proposal is an attempt by the DoD to structure a competitive environment, or at least one that simulates a competitive environment based on cost, timing, and quality, including past performance as a proxy for future performance. At the same time, the DoD itself is regulated by a set of internal regulations that are meant to ensure that the DoD is acting in an honest and prudent manner. Although particular regulations are likely to be aimed at only one of the three—the contractor's operation, the product, or the government system of solicitation and contract management—these often interact so that the enforcement of product specifications becomes a government or a DoD responsibility.

A major area of concern in regulation is the "right" of any potentially qualified bidder to bid on contracts, and the obligation of the DoD or government purchasing agent to ensure that all such potentially qualified bidders are aware of the interest of the DoD in the purchase. This is a right that has no analogy in the private sector.[34] The taxpayer's interest—that a fair price be established—can be met through separate less onerous regulation. Such regulation would depend on having the DoD agent perform market analysis to be sure that there are sufficient qualified contractors for a competitive procurement. In this way DoD could bring government procurement practices closer to commercial practices and paradoxically make the government market more accessible to a wider range of firms.[35]

Although overlooking a contractor would be unfortunate and might deprive the DoD of a better or less costly product, it would be no different than a buyer in a commercial firm who overlooks a potential supplier. What is different for the DoD is that the law gives "all qualified vendors" an interest in the competition. It is this complication that allows any "interested party," i.e., any ""actual or prospective offeror whose direct economic interest would be affected by the award of a contract or by the failure to award a contract,"[36] to question and to lodge formal protests during any part of the procurement

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[34] The law gives "all qualified vendors" an interest in the competition. It is this complication which allows any "interested party, " i.e., any "actual or prospective offerer whose direct economic interest would be affected by the award of a contract or by the failure to award a contract," to question and to lodge formal protests during any part of the procurement process.

[35] See "Federal Acquisition Regulations System," 48 CFR Ch. 1, Part 6, "Competition Requirements," pp. 82 ff.

[36] See "Federal Acquisition Regulations System," 48 CFR Ch. 1, 33.101, "Protests," p. 734.

process. There is a need to bring DoD solicitation in line with common business practices by eliminating this practice by regulation, if possible, by law if necessary.

4. Auditing and Oversight

One of the difficulties with regulation is that its enforcement is not costless. A large part of the DoD is now devoted to oversight and auditing. The difficulty with this process within the DoD is that now large parts of the Department are concerned more with oversight of regulations than with accomplishing the original purposes of the laws and regulations. As pointed out earlier, the DoD regulatory process has conflicting purposes. Moreover, some rules may be costly to enforce, indeed so costly that the enforcement may vastly exceed any savings that may come from the oversight. Finally, some approaches to oversight may lead program managers and contracting officers pursue to inefficient approaches rather than risk being accused of breaking regulations and subject to penalties.

C. CONTRACTOR ACTIVITIES

The second broad class of regulations is targeted at firms that contract with the DoD. These include cost accounting standards, "how to manage" standards, social, environmental, and workplace standards, export controls and information protection, and limitations on the supplier base. These kinds of regulations provide the major administrative barriers to entry into the defense markets.[37] Better tailoring of these requirements will contribute substantially to the integration of the defense and commercial supplier base. Hence, action on these regulations is a key component of a reconstitution strategy.

1. Cost Accounting Standards and Other Cost and Financial Reporting Systems and their Certification

The DoD and U.S. government's interest in the cost accounting of the contractor stems from its use to establish the "fair" price for a product. However, in determining a fair price, there are and should be many other factors considered, quality, time, point of delivery, guarantee period etc. Moreover, when the price for an item can be established in the competitive marketplace, then cost is irrelevant. If the competitive price at a point in time is much higher than the cost, the price will be driven down eventually. The

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[37] See for example, *Holding the Edge*, op. cit., pp. 172-176.

difficulty comes, of course, when the market lacks competition. Then there is some attempt to estimate what the market would or ought to do through imposition of reporting systems that attempt to provide information to the DoD on the "true" cost of the product, as well as on how the firm is managed, on whether the employer treats its employees fairly, and a myriad of other issues.

Some of these issues are treated in later sections of this paper, but they are treated here under the issue of reporting. It should be pointed out first that reporting systems in themselves, even when implemented in an efficient and honest way, do not necessarily assure validity even when they assure precision; that is, they frequently are not measuring what the DoD would really like to know. In particular, with respect to costs and the CAS or any other system of cost accounting, the allocation of overhead costs is arbitrary, and even rules on direct costs will result in arbitrary, but consistent allocations.

Once the DoD is in the business of measuring what an item costs, it is also in the business of trying to make sure the contractor does not earn "excess" profits. Since profits might be hidden in various overhead accounts, such as Independent Research and Development (IR&D) and Bids and Proposals (B&P)—both of which are not, strictly speaking, necessary to complete the current contract—it is in the business of determining whether the spending in such accounts is proper, and indeed of telling companies how to run their business.[38]

That the DoD itself does not rely on the contractor's cost system to determine fair price is verified by the many other approaches it uses to determine the "right" or "fair" price. These include such approaches as value engineering[39] and "should cost" systems that purport to tell the DoD customer what an item should cost, as an alternative to what the contractor's accounting system says it costs. Beyond that, the DoD, through engineering and statistical cost estimating techniques and through simple analogy, estimates what systems should cost and uses such estimates to challenge the contractor or program manager.

Most frequently these other techniques are used to compare projected contractor cost estimates, but the techniques also are used to challenge the cost claims and other

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38 See "Non-Mandatory Advanced Agreements on Allowable IR&D and B&P Costs," by Lt. Commander Joseph R. Endres, USN, Dr. James M. Fremgen, *Program Manager*, November-December, 1990, pp. 22-31.

39 See later section of this paper on "How to Manage Standards" for a discussion of value engineering and related programs. See for example, *Holding the Edge*, op. cit., pp. 172-176.

historical costs of the contractor and program office.[40] These other techniques merely underscore not that the CAS system is flawed, but that many in DoD believe that they can establish through other cost estimating techniques that the costs of an item are high.

The special burden of applying the Cost Accounting Standards has been given recent emphasis.[41] It is interesting that there is so much contention concerning the difficulty of interpreting and applying the CAS, since their original purpose was to simplify the work of the contracting officers and relieve them of the responsibility of interpretation. According to the GAO, contracting officers had:[42]

> ...the entire burden...to evaluate the contractor's accounting practices without the guidance of authoritative support for the use of alternatives in specific circumstances. [This results] in more work for auditors and procurement officials, delays in important technical work, and excessive procurement costs.

Stress was laid on consistency of contractor accounting practices with recognition that circumstances might dictate differences among contractors. Emphasis has been on extending the CAS and disclosure beyond cost-type contracts "to negotiated procurement contracts and subcontracts, both cost type and fixed price."[43] This extension has been due to the concern that a contractor with cost reimbursement contracts would charge costs that were properly part of a fixed-price contract. It is not clear whether the GAO report recognized a difference between firms that were mainly doing commercial work, and those that were mainly doing business with the government.[44]

The major purpose of special regulation should be to get good military systems and other products for the DoD at the lowest cost, where the value of the system to DoD will include timeliness, reliability, reconstitution capability and other dimensions of the product, and where the cost includes the operating cost of the system and the internal

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40 For a discussion of the various concepts and approaches to costs, see Gene H. Fisher, *Cost Considerations in Systems Analysis*, A Report prepared for the Office of the Assistant Secretary of Defense (Systems Analyses), American Elsevier Publishing Company, New York, 1971. The book includes a discussion of various concepts of costs and various approaches to estimating costs.

41 See *Integrating Commercial and Military Technologies...*, op. cit., Chapter III, "Accounting Requirements," This report lays out the special problems of meeting DoD and U.S. Government accounting requirements.

42 Comptroller General Report to Congress, B-39995, under Public Law 90-370, as reported in *Cost Accounting Standards Guide*, CCH Editorial Staff Publication, Commerce Clearing House, Inc., 1990, ¶ 2900-2910, pp. 4021-4028, quotation from p. 4022.

43 Op. cit., p. 4027.

44 For a brief history of the cost accounting regulations back to 1940, see Endres, and Fremgen, op. cit., pp. 23–24.

DoD and contractor costs of policing the system, since these costs in the long term all will be paid by the DoD. Where there is a market in which comparable products can be priced, it should not be important to DoD to know what the product cost. Indeed the only way DoD can know if it paying too much is by comparing the product with the cost of other items. Buying a product based on its cost only reveals the profit level of the contractor and not whether the DoD is getting its money's worth. Moreover, the costs, as mentioned elsewhere, include arbitrary allocations of both direct cost and overhead: there is no such thing as the true cost of an item.

That estimates based on accounting costs are not always the most useful has been recognized by the DoD and by the Congress in the institution of the Cost Analysis Improvement Group (CAIG), wherein aggregated cost-estimating methods are used to develop independent cost estimates in order to measure the reasonableness of the cost estimates given by contractors and program offices.[45] Even when documented contractor costs are being reported, DoD officials and many in Congress will believe the independent cost estimate based on historical costs of comparable systems.

2. Eliminating Special DoD or USG "How To Manage" Standards

As discussed in the previous section, many standards imposed on the contractor have little to do with the functionality of the product or even its specifications, but rather are often attempts to monitor the management techniques of government contractors in delivering the product. They frequently are sufficiently detailed that a contractor must go beyond demonstrating that it conforms to the standard based on generally accepted practice, e.g., the fact that it has a quality control program, and that it has delivered quality products without flaws will typically not be sufficient to demonstrate conformance with the standard. Such standards increase the burden on the contractor and hence the cost to the government without a commensurate increase in the value of the product. Moreover, if integrated into the business, they would increase the cost of commercial products made by that firm. These standards while not necessarily useful for improving defense firm performance, provide an obstacle to involvement of commercial firms in defense production. Therefore they should be eliminated or at least tailored to accommodate standard industry practice.

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45 See "Criteria and Procedures for the Preparation and Presentation of Cost Analyses to the OSD CAIG," enclosure 1 to "OSD Cost Analysis Improvement Group," DoDD 5000.4, October 30, 1980.

3. Programs with Social, Environmental and Workplace Goals

In addition to those standards, regulations, and other governing documents that attempt to tell contractors how to manage their businesses, there are other provisions that advance social goals, and some which may straddle the two categories (see Table III-3).

Table III-3. Non-Procurement Objectives and Selected Programs

Objective Category	Program
Labor standards	Walsh-Healey Public Contracts Act Service Contract Act Davis-Bacon Act
Discrimination and affirmative action	Race Sex Handicapped Age Veterans
Business set-asides	Minority Business Indian Business Women-Owned Small Business
Environment, conservation, drug-free workplace	Environmental Protection Energy Conservation Hazardous Materials Control Drug-Free Workplace
Privacy and freedom of information	Privacy Freedom of Information
Foreign acquisitions	Buy American Act Buy Canadian

Source: *Government Contracts Reporter*, Vol. I, CCH Business Law Editors, Commerce Clearing House, Inc., 1992, 3000-3230, pp. 1909-1922.

In the former category are equal opportunity and affirmative action, and the Walsh Healy Public Contracts Act provisions that go beyond the requirements the law makes for firms that are not federal contractors. The Walsh Healy Public Contracts Act covers minimum wages, overtime, child and convict labor, and health and safety. As is typical of many laws applicable to DoD and the government, it duplicates laws that apply to the rest of the economy, but with slightly different records, requirements, or responsibilities involving subcontractors and suppliers.

Many programs that involve social goals go beyond more general laws that apply to whole economy and to all companies, or to all companies above a certain size. Such programs, e.g., those to promote small business, are specific to DoD or the government,

and they place an extra burden on defense. In order to expand the defense industrial base, firms that already are required to obey laws and pursue programs involving such social, environmental and workplace goals should not have to set up separate record keeping and enforcement systems to adhere to slightly different laws involving discrimination, health and safety, and the DoD should not have to require special certifications of a firm for it to become a defense contractor.

The tailoring of regulation in this area would be aimed at treating DoD contractors the same as other firms engaged in interstate commerce. Thus the array of programs and regulations that apply to General Electric or Boeing as commercial firms should apply to them as DoD contractors. What presents a problem is setting up a second set of reporting requirements for DoD or the federal government.

4. Information Protection and Export Controls

One of the major roadblocks to reconstitution is that the DoD, in attempting to enforce its property rights and in enforcing its classification and information protection program, places major roadblocks in the way of integration of the defense industry with commercial firms and other private organizations. These goals of enforcing property rights and protecting information from open disclosure will conflict with the goal of integration and promotion of the dual use of information and technology. These conflicts are inherent, and any program to promote civil-military integration of industry and technology and the dual-use of technology will have to take this conflict into consideration. To the extent that the DoD finds it difficult to cooperate with foreign firms in normal times, the strong capabilities that exist abroad may be denied during a reconstitution period.

A major conflict that gets in the way of integrating the defense industrial base with the civil economy and civil research establishment has to do with two aspects on information policy. The first involves the intellectual property rights, i.e., whether information that was or may have been developed at least partially with government funds belongs to the government or to the contractor. The second involves the difference between the particular way the government protects information—classified and unclassified. Much of the information is protected through the national security

classification system,[46] while other technology is protected under the Arms Export Control Act and a set of related laws.[47] These all were developed during the Cold War and ought to be reviewed and rationalized in the light of the new DoD environment.

The system of property rights, usually raised under the issue of technical data rights, has created roadblocks to the participation by a commercial firm when privately created technology is to be used for DoD projects.[48] The DoD may limit the subsequent exploitation of the product, may make the firm pay the government a recoupment charge for using what the firm considers to be mostly its own information, or may force the firm to turn over trade secrets to a competitor. The firm may be concerned that the government will protect its information in an inadequate fashion. There is a certain irony in this last point, because the complaint is normally that the government is protecting its information too well, rather than not well enough.

With respect to classification, the system limits information-sharing to other organizations that are part of the security system and to individuals that have security clearances. By its nature, sharing is prohibited with purely commercial firms that have not gone through the security process, or firms that would not want to risk having its company-owned technology considered classified might be reluctant to be involved in adapting its technology to DoD needs.[49] It has been recognized over the years that excessive security classification has been a major problem. The scope of security classification and the protection of such information should be reviewed with a view to reflecting the increasing dependence of the DoD on the commercial sector.[50]

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46 For a history and background of the classification system see Arvin S. Quist, *Security Classification of Information*, by Volume 1, Introduction, History, and Adverse Impacts, K/CG--1077/VI, September 1989.

47 See *Balancing the National Interest, U.S. National Security Export Controls and Global Economic Competition*, Panel on the Impact of National Security Controls on International Technology Transfer, Committee on Science Engineering, and Public Policy, National Academy of Sciences, National Academy Press, 1987, Chapter 4, "The Dimensions of National Security Export Controls," pp. 70-102.

48 For three examples of industries where this is said to be a problem are fiber optics, advanced composites, and software. See, *Holding the Edge*, Volume 2, op. cit., pp. 71-72, 91-93 and 111-112. The federal government has recently improved the situation by reducing the requirements for recovering government costs from firms using jointly paid for R&D and other non-recurring costs in connection with commercial and other non-government products. See, "White House Renounces Recoupment Policy; Industry Focuses on Congress," *Inside the Pentagon*, June 25, 1992, pp. 12-13. Article includes the White House press release announcing the change in policy.

49 See *The Governments Classification of Private Ideas*, Thirty-Fourth Report by the Committee on Government Operations, House Report 96-1540, 96th Congress, 2nd Session, December 22, 1980.

50 See "Pentagon to Overhaul Policies on Secrecy Procedure," by Neil Munro, *Defense News*, September 14-20, 1992, p. 6. The article discusses a memo approved by Duane Andrews, Assistant Secretary of

A similar problem exists with export controls. The Arms Control Export Act and several related laws restrict the flow of both classified and unclassified information to non-U.S. citizens. Both DoD and NASA apply their own export control markings to information generated by their contracts.[51] Such restrictions discourage firms from trying to exploit defense-related technology, knowing that exports will require licenses, and that the flow of information concerning such products will be restricted.

Export controls are generally related to national security, restricting the proliferation of possibly dangerous products and dual-use technologies, but some controls serve other foreign policy goals.[52] Because the range of dual-use technologies is so broad, the controls subject a broad range of technologies and type products to special licensing requirements.[53] Because of different priorities and degree of enforcement these licensing requirements have given a competitive advantage to competing non-U.S. companies whose export control procedures are less cumbersome.[54] This limiting of the market has reduced the potential return on products that are on the world market, and thus has reduced the incentive to invest in the development of systems.

Also the U.S. government has an asymmetric set of rules on export control in which it limits the actions of other countries and foreign contractors in their transactions with third counties, while it wishes to preserve its own freedom of action with respect to third countries. U.S. export control laws and regulations have prescribed the military uses and flow of all U.S. technology outside the U.S., regardless of the laws and customs

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Defense for Command, Control, Communications, and Intelligence, which would, among other things, cut down on the amount of classified material by identifying the most critical information that needs to be protected and relaxing controls on the rest.

51 See Section 1217, Defense Authorization Act for FY 1984, which gave the Secretary of Defense the ability "...to protect export-controlled technical data of such military significance that release for purposes other than direct support of DoD-approved activities may jeopardize an important technological or operational military advantage of the United States." This is implemented in DoDD 5230.25, "Withholding of Unclassified Technical Data from Public Disclosure," November 6, 1984.

52 See *Finding Common Ground: U.S. Export Controls in a Changed Global Environment*, Panel on the Future Design and Implementation of U.S. National Security Export Controls, Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Sciences, Washington, DC, 1991, pp. 63-79.

53 See *The Military Critical Technologies List*, Volume I, List of Militarily Critical Technologies, Office of the Under Secretary for Acquisition, Washington, DC, October 1989. The list contains 20 categories and over 250 detailed categories. Although being on the list does not automatically subject an item to controls, it puts the potential developer and producer of an item on notice that he runs a major risk of delay in exporting any item involving a technology on the list.

54 Op. cit., pp. 19-20 and section on "Basic Problems of the U.S. Export Control Regimes," pp. 86-105.

of other countries. As a result, U.S. contractors have been excluded from certain programs outside the U.S. and foreign firms have refused in certain instances to be involved in U.S. projects. Overall, this has the result of preventing the U.S. from having available the most advanced technology. The transformed world security arena, as well as the increased world-wide availability of advanced dual-use technologies, requires that export controls be fundamentally revamped with explicit attention to limited dual-use controls.

CHAPTER IV. LINKING SCIENCE AND TECHNOLOGY TO FLEXIBLE PRODUCTION

Rapidly fielding superior weapons from a flexible, integrated civilian-military technology and production base should be the heart of DoD's reconstitution strategy. Achieving this goal depends on two interrelated assets that the country must sustain and adapt: the technology and engineering base, and the production base. Most importantly, it depends on how well these are integrated into a responsive, flexible manufacturing system. To achieve a technological capability that can be scaled up to producing needed military systems, DoD needs to draw upon (1) knowledge of and experience in applying advanced science and technology; (2) experienced and adaptable engineering and production teams; and (3) the tools, methods and facilities for flexible systems design, development and production.

In this chapter we discuss first the evolution of DoD's separate R&D capabilities and the need for these to give way to a more integrated (defense and commercial) R&D and production base. Next we examine the future defense science and technology base—what it has to gain from and what it has to contribute to integration—and how to get started. Finally, we consider the way in which technologies for improving systems design, engineering, and production can make reconstitution more achievable.

A. DEFENSE TECHNOLOGY STRATEGY

1. The Cold War Legacy[1]

America's post-war military and industrial capabilities built upon advances in technologies that were fostered by the huge infusion of research from World War II. Nuclear weapons and propulsion, ballistic missiles, satellites, turbine engines, radar, sonar, and electronic computers all originated from defense needs and intensive R&D

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[1] See Richard H. Van Atta, Seymour Deitchman and Sidney Reed, *An Overall Perspective and Assessment of the Technical Accomplishments of the Defense Advanced Research Projects Agency: 1958-1990, DARPA Technical Accomplishments, Volume III,* Alexandria, Va.: Institute for Defense Analyses, P-2538, July 1991, for a more detailed review of defense advanced R&D from the early Cold War period to today.

activities. Immediately after the war, the United States placed its priorities on demobilization and the revitalization of the domestic civilian economy, concurrently with efforts to rebuild the devastated economies in Europe and Asia.

The wartime experience and benefits of directly channeling the scientific and technical assets of the nation's universities and research institutions into developing new technologies and weapons capabilities were seen as providing an important model for applying science to meeting postwar domestic needs that country faced. Vannevar Bush, the Director of the Office of Scientific Research and Development during the war, wrote his highly influential tract, *The Endless Frontier*, advocating a continuation of government-promoted science programs after the war for "the improvement of national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living."[2] While having marked influence on the concept of U.S. policy in science, eventuating in the National Institutes for Health and the National Science Foundation and a strong focus on federal support for scientific research in universities, the concept of a major re-orientation of national research priorities toward broad domestic challenges was offset by the emergence of the Soviet Union as a threat to the international order.[3]

The political confidence with which the U.S. entered the post-World War II era was soon shaken by the capacity of the U.S.S.R. to field rapid advances in military technology. These advances made the Soviet Union a threat to the continental United States in ways this country had never experienced—the detonation of a nuclear device by the Soviets in 1949, and of a thermonuclear device in 1952, came as successive shocks that began to awaken the U.S. to the challenges ahead. On October 4, 1957, the Soviets launched Sputnik, raising the specter of the U.S.S.R. as an immediate technological threat to the United States. This "surprise" demonstrated the lack of attention which was being paid by the U.S. to Soviet technological capabilities and priorities in space and missiles, and their implications for national security. It raised the issue of scientific and technological expertise at high levels in DoD, providing the impetus for the creation of both the Advanced Research Projects Agency (ARPA) and the position of Director,

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2 Vannevar Bush, *The Endless Frontier*, Report to the President, Washington, D.C.: USGPO, 1945.

3 Harvey Brooks, "National Science Policy and Technological Innovation," in Ralph Landau and Nathan Rosenberg, eds., *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington, D.C.: National Academy Press, 1986, p. 124.

Defense Research and Engineering (DDR&E). These decisions were to have a substantial impact on the evolution of technology policy and programs within DoD.

2. The Changing Environment for DoD's Technology Strategy

DoD now is trying to understand and respond to a changed, but highly unclear and uncertain environment. Key givens of the past 50 years have changed, raising important questions concerning the appropriate DoD technology strategy. These givens also have changed simultaneously, and they challenge some of the basic policies and predispositions within DoD and the larger policy arena.

In particular, three aspects of this changed environment call for a fundamental change in DoD's approach to technology development: (1) the changing political-military environment with the declining Soviet (Russian) threat removes the relatively clear focus for DoD's technical requirements and demands, and reduces the resources available to meet those demands; (2) the U.S. leadership in technology is now challenged—advanced technology relevant to defense capabilities is increasingly available worldwide; (3) within the U.S., the relationship between defense and commercial sectors has changed with DoD becoming increasingly reliant on commercially-developed technology. These changes in the Defense environment must be addressed through coherent programs that link defense R&D to broader government programs based on changing requirements (see Table 4-1 below).

Recent policy reviews have stressed that the country should seek an integrated industrial and technology base—unifying defense with commercial industry.[4] For economic and efficiency reasons, DoD must rely more on commercial components and technologies. This means the line that traditionally has been drawn between R&D for defense applications versus those for civilian uses is becoming itself an impediment. There is substantial overlap in technology and DoD is not always the leader or even the main driver of government funding. DoD must rely increasingly on the commercial base. How is DoD to cope with this new environment?

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[4] *New Thinking and American Defense Technology*, New York: Carnegie Commission on Science, Technology, and Government, August 1990, pp. 24-27.

Table IV-1. The Changing Environment for Defense Technology Strategy

Environment	Yesterday	Today
Military Threat	Soviet threat drives DoD R&D (Imperative for highest technical capabilities to compensate for U.S.S.R. quantity).	Soviet threat gone—unclear focus for R&D. (Imperative for highest capabilities gives way to affordability criterion.)
U.S. in the World	U.S. leads in almost all key technologies.	U.S. technology leads dissipated—particularly in production and manufacturing.
	U.S. dominates most industrial and hi-tech markets worldwide.	U.S. position declining in industrial and hi-tech markets worldwide.
DoD/ Commercial Technology in the U.S.	DoD develops and uses advanced technology ahead of commercial sector.	Commercial sector leads in using many advanced technologies.
	Commercial sector adapts technology spin-offs from defense R&D.	DoD looks for commercial technology that can be dual-use.

3. Criteria for a Robust Science and Technology Base—Defining Success

The criteria that DoD should use for shaping its investments in the science and technological base should reflect this changing global security environment. When the U.S.S.R. posed a military threat that had strategic reach to the Continental U.S., these criteria were focused on: (1) developing and fielding military capabilities that overcame the numerical advantages of the U.S.S.R. and (2) continually redefining the terms of the competition in the area of greatest leverage for U.S.— advanced technology.[5]

Even as the flow of technology was changing and DoD-sponsored work was losing its lead relative to the commercial sector, DoD's R&D efforts still attempted to deploy the "best" technology so as to outflank the adversary qualitatively and drive him out of the competition. Cost, ease of transition into operations, and any concept of linking defense to civilian technology were generally secondary considerations.

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[5] See *Defense Science and Technology Strategy*, Director of Defense Research and Engineering, Department of Defense, July 1992, p. I-4, for brief discussion of "Cold War S&T Drivers."

Given the changed security environment and the leadership of commercial industry in most dual-use technologies, the criteria for successful defense R&D need to be changed to—

[1] *Affordable Performance.* Use technology to leverage performance relative to system acquisition and ownership costs;

[2] *Improved transfer of commercial technologies and practices into defense applications.* Adapt advanced commercial technologies and processes (domestic or foreign) into military-specific applications;

[3] *Flexibility and integration of production.* Design of weapons should emphasize their rapid transition into production; create flexible development and production systems integrated with the commercial product development and production facilities of the country;

[4] *Improve viability of dual-use product and process technologies.* Continue support for advances in "dual-use" technologies, especially the processes for more flexible production of dual use technologies.

Success of this strategy for reconstitution would be evidenced by sustained U.S. capabilities to innovate and produce goods that improve the competitive economic and technological position of the United States in "dual-use" areas of particular relevance to advanced defense systems production. Without a robust manufacturing capability, the strategy of integrating defense and commercial technology and production would be severely undermined.

This concept of "success" should include criteria or measures of the "mechanisms" or processes for achieving the overall technological competitiveness goal. As part of the implementation of this strategy, such indicators of success might include the degree to which worker training is improving; measures of the number of companies that adopt new approaches to technology commercialization; the number of industries and companies engaged in technical information sharing and cooperation programs; investment in new, flexible manufacturing processes; increased R&D by companies; and re-orientation of federal, state and local budgets to technology development and transfer.

Regarding criteria for defense R&D, the integration of the DoD products and processes with those of commercial industry will blur the line between defense and civilian R&D programs. Clearly, there must be some articulation in the overall technology programs of how defense technology developments and procurements are to be intermeshed with the overall national agenda. If DoD continues to pursue its R&D

programs (even if increasingly "dual-use") in isolation from civilian R&D agencies, it will both waste resources and potentially undermine our future security.

B. THE FUTURE DEFENSE SCIENCE AND TECHNOLOGY BASE

1. Defense, Science and Technology in a Changed Global Environment

The changing "post-Cold War" environment provides a substantially reduced security threat, and some have argued that the imperatives for defense R&D have subsided. Yet, the Secretary of Defense and others have cautioned that the perturbations in the former U.S.S.R. are still so recent, their effects so encompassing, their outcomes so uncertain, that prudence requires continued effort to develop effective defense technology. Moreover, much of DoD's technological focus is on enduring problems, such as ASW, precision strike, and global reconnaissance—problems that are relatively generic and were not specifically driven by the Soviet threat. Given the demise of the U.S.S.R., these thrusts might be revamped in their particulars, but their overall motivations and goals are still justified. The tractability of the threat is replaced by the uncertainty of where future threats to U.S. security will arise. This places premiums on DoD's programs on surveillance, information processing for command and control, training technologies. It also increases the importance of bringing technology to bear on achieving very rapid but effective responses to threat situations.

Both the Executive Branch and the Congress are committed to a robust Defense S&T program, planning for it to grow despite the overall cutbacks in the defense budget. DoD's science and technology strategy and programs recently have been substantially revised to reflect these new imperatives.[6] The Defense S&T community has identified seven technology "thrust" areas central to the creation of next-generation forces. These are: Global surveillance and communications, precision strike, air superiority and defense, sea control and undersea warfare, advanced land combat, synthetic environments (simulated environments for training and planning), and technology for affordability.[7]

The latter two thrust areas directly support the goals of the reconstitution strategy because they focus on developing the kinds of design and manufacturing tools that will increase DoD's flexibility to rapidly field new weapons. The changing world situation

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6 Ibid., pp. I-6 - I-16.

7 Ibid., p. I-18, and Section II.

raises the need for redirecting technology away from providing the "most advanced" technology to meet the threat, toward using technology to make effective defense less costly. In an era when priorities are being placed on reducing defense budgets and seeking resources to deal with domestic concerns, the DoD S&T thrust on technology for affordability is especially important.[8]

Within each S&T thrust area, a range of advanced technology demonstration (ATD) projects are to be undertaken to prove out both product and manufacturing technologies. Before a technology development is even considered to be moved from the science and technology program into the acquisition process, exit criteria must be passed to assure that the technology being demonstrated by an ATD is "ready and affordable, manufacturing processes are available, and operating concepts are understood."[9] If ATDs are managed effectively according to these criteria, the time needed to incorporate the technologies into weapons programs will be reduced. The science and technology program currently proposed by DoD promises to provide a sound base of proven, producible technologies for reconstitution.

Suggesting DoD focus greater efforts on issues of weapons systems costs, and the time it takes to design, develop, and produce weapons systems, puts greater emphasis on its programs associated with manufacturing technology and the more generically oriented programs in information systems that could affect the industrial production infrastructure. This raises specific questions regarding DoD's R&D strategy: production technology generally is developed and implemented by industry and most such technologies are not defense-specific. Moreover, DoD has excelled in what the nation overall has excelled in—the development of new, creative technological concepts that render obsolete existing approaches.

The problem for DoD, much like American commercial industry, is that its technology development system has been optimized for creating *new* product concepts and designs, as opposed to developing and perfecting more efficient ways of *producing* them. In essence, the defense affordability issue is a parallel for DoD of America's overall competitiveness problems—the ability to economically transition advanced

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8 Ibid., discusses this role under S&T Thrust 7, "Technology for Affordability," pp. II-65-II-73.

9 Under Secretary of Defense Don Yockey, Memorandum on "Defense Acquisition", Department of Defense, 20 May 1992, p. 3. Under Secretary Yockey notes that technology demonstrations are not new. What is new is the scope and depth now envisioned, their increased importance in the acquisition process, and the increased involvement of military users in guiding and evaluating the demonstrations. See *Defense Science and Technology Strategy*, op. cit., p. I-16.

concepts into efficient production in a timely manner. The declining DoD budget has underscored a problem in DoD that is parallel to the loss of market share and profits for commercial U.S. industry, i.e., the need for "competitive" production. The concepts of more efficient, "affordable" defense production and more competitive civilian production then are cut of the same cloth. The question for DoD is how can it best deal with improving the efficiency of defense production—manufacturing —*in concert* with U.S. industry overall.

The realm of manufacturing technology in DoD has not had a consistent focus, and in general has been something of an after-thought. Manufacturing-related R&D has been an organizational orphan, as the research organizations concentrate on investigating new phenomena, such as lasers or superconductivity, or on designing, developing and demonstrating new capabilities of systems, subsystems, or components. The production community on the other hand has concentrated on overseeing and managing procurement programs through their milestone decisions. This acquisition program management realm has relatively little generic interest in production processes; rather, such processes are of concern only as they affect the production cost and schedule of a particular system.

2. Focusing the Defense Technology Strategy on Integrating the Technology and Industrial Base

There is a growing need to integrate DoD's technology development and production with the overall technical and industrial capabilities of the country. From DoD's perspective, this raises the following concerns:

- What should be the Defense Department's role in supporting the nation's technology infrastructure?
- What should be the relationship between DoD R&D programs and the civilian and commercial availability and applications of technology?
- How can DoD integrate its procurement and production with the overall national industrial base to meet its low volume requirements, but also provide for possible rapid surge production in crisis or wartime?
- Given the growing dependence of commercial manufacturers on foreign sourcing for critical subsystems, components, materials, and precision tooling, can DoD accept the degree of foreign content for its systems that now exists in many commercial industries?

- What policies and programs are needed to more rapidly and effectively transition technology into application and in particular to transition *commercial* technology into defense systems?

The Science and Technology Strategy promulgated by the DDR&E recognizes the need to channel defense technology development away from that pursued during the Cold War to a new strategy that responds to a more uncertain, less well-defined threat, and one that does not entail "a large-scale struggle for national survival."[10] It also recognizes that this must be done under severe budgetary constraints, such that affordability must be a fundamental aspect of all defense R&D and procurement. The S&T strategy heralds the transformation of defense R&D away from a motif that sought the best without regard to cost, to one that seeks the best within the constraints of limited and decreasing budgets.

In our assessment, a key element of this shift in strategy should be the relationship of the new approach and focus of defense R&D to the overall base of the country to develop technology and produce applications—useful products —from it. A primary concern ought to be the proper integration of DoD's S&T programs into an overall national technology strategy. The questions of relevance are within this role: what should be DoD's programmatic thrusts; how should these be linked to the technology development programs of other government agencies—*and what should these be*; and how should these all be pursued in relationship to the changing industrial capabilities of the country?

3. Specialized Defense Technologies

Some technologies are, or should be, dependent exclusively on the support and interest of the DoD. These include technologies related to nuclear weapons, missiles and rockets, munitions, and certain aspects of undersea warfare. However, even such "purely military" systems depend on dual-use technologies, e.g., electronics, software, computers, materials. Thus, even for these systems greater integration with the commercial economy and the civil research structure is desirable.

There always will be some products unique to the military: warships, missiles, and nuclear weapons are examples. The country must be able produce these for the base force, and be able to produce them in larger numbers for reconstitution. Their development and production in the past has been done largely by specialized defense

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[10] Ibid., p. I-5.

firms, in specialized defense facilities, with a specialized labor force. In the future, these military systems will continue to require some specialized technical and industrial support, certainly in research, and perhaps with limited production facilities and, in unusual cases, a specialized labor force with skills not generally available in the commercial economy. The need for such facilities or labor force will depend on the time it will take to build such facilities or train such a labor force, the value of doing this relative to substitutes, and the time horizon for reconstitution. But much is being done to reduce the need for specialized, or standby, facilities. And much more should be done in DoD's R&D strategy to eliminate such requirements and further the integration of defense development and production into the overall national industrial base. This should be made a high priority of the defense technology strategy.

4. Integrating Defense With the Civil S&T Program

Even without the concerns about the declining defense budget and considerations of reconstitution, the issue of dual-use technologies and the dependence of defense on the civil (both government and private) science and technology base would have become an important consideration. The Carnegie Commission on Science, Technology, and the Government noted that DoD funding had dropped from half to one-third of all U.S. R&D spending (this change having taken place even given the buildup of the late 1970s and the 1980s). At the same time, it noted a rise in the importance of foreign technology. The Commission went on to suggest that these two changes required that "DoD needs to draw upon the much larger commercial technology base" and that "the nation's economy ... needs to benefit from DoD's still large expenditures on technology."[11]

DoD science and technology policy and strategy have not explicitly reflected this integration. The two most recent documents that DoD has produced on S&T strategy, *The Defense Science and Technology Strategy* and *The DoD Key Technologies Plan*, focus narrowly on the national security aspects of technology development with little regard to relating this develop-ment to the rest of the government or the commercial industry. Yet, a number of government and industry panels have shown a "...substantial overlap ... between those technologies essential for national security and those that contribute to economic competitiveness." This is shown in Table 4-2.

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[11] *New Thinking and American Defense Technology*, op. cit.

Table IV-2. Comparison of Critical Technologies Lists*

National Critical Technologies	DoC Emerging Technologies	DoD Critical Technologies
Materials • Materials synthesis and processing • Electronic and photonic materials • Ceramics • Composites • High-performance metals & alloys	• Advanced materials • Advanced semiconductor devices • Superconductors } Advanced materials	• Composite materials • Semiconductor materials and microelectronic circuits • Superconductors } Composite materials
Manufacturing • Flexible computer integrated manufacturing • Intelligent processing equipment • Micro- and nanofabrication • Systems management technologies	• Flexible computer integrated manufacturing • Artificial intelligence	• Machine intelligence and robotics
Information and Communications • Software • Microelectronics and optoelectronics • High-performance computing and networking • High-definition imaging and displays • Sensors and signal processing • Data storage and peripherals • Computer simulation and modeling	• High-performance computing • Advanced semiconductor devices • Optoelectronics • High-performance computing • Digital imaging • Sensor technology • High-density data storage • High-performance computing	• Software producibility • Semiconductor materials and microelectronic circuits • Photonics • Parallel computer architectures • Data fusion • Signal processing • Passive sensors • Sensitive radars • Machine intelligence and robotics • Photonics • Simulation and modeling • Computational fluid dynamics
Biotechnology and Life Sciences • Applied molecular biology • Medical technology	• Biotechnology • Medical devices and diagnostics	• Biotechnology materials and processes
Aeronautics and Surface Transportation • Aeronautics • Surface transportation technologies		• Air-breathing propulsion
Energy and Environment • Energy technologies • Pollution minimization, remediation, and waste management		• No national critical technologies counterpart: high energy density materials. Hypervelocity projectiles, pulsed power, signature control, weapon system environment

* *Report of the National Critical Technologies Panel*, U.S. Government Printing Office, Washington, D.C., March 1991, p. 5.

The National Critical Technologies Panel further notes that:

> Although a small number of highly defense-specific DoD Critical Technologies (e.g., signature control, pulsed power, and high energy density materials) are not included among the National Critical Technologies, most of the DoD technologies are "dual use" in nature, and potentially are as important for their non-defense applications as they are to DoD.[12]

Thus, in the future the DoD should seek to coordinate and integrate its strategy and programs for technology development with those of other government departments and with commercial industry. It should strive to achieve a balanced technology investment portfolio that does not excessively support some areas that receive substantial support from other sources, and not neglect areas of critical importance to both the national economy and the national security because it assumes that technology is being adequately supported elsewhere. At the same time, the multiple sources of funding is a strength in the U.S. system and there should not be any attempt to impose a central control mechanism on technology base funding that allocates funds in detail.

The integration of DoD technology development into a broader national technology strategy is essential to ensure that the technologies developed by DoD can be produced efficiently within the overall industrial capabilities of the U.S. with minimal requirements for defense-specific production facilities or capabilities. In our view, DoD must direct its focus and resources, and make the organizational changes needed, to adequately seek commercial and civilian technologies and apply these to meeting defense needs.

5. DoD and Technology Transfer

An area that should be given much greater focus in DoD's technology strategy is the transitioning of technology into application. Providing mechanisms for commercial application of DoD-developed technologies benefits the Defense Department directly. Such cooperation can extend the application base of DoD R&D, and thus reduce the cost of defense applications and make available a broader base of experience regarding application potentials. However, for DoD to benefit from such relationships, new approaches to the development of the technologies themselves are needed. The relationship between military and civilian R&D must be considered as part of the defense

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12 See *Report of the National Critical Technologies Panel*, USGPO, Washington, DC, March, 1991, p. 4.

technology development process, rather than being a post hoc program in which DoD attempts to "spin off" research that commercial industry can use. A two-way street that is mutually supportive must be developed, or else the so-called technology transfer program will be primarily contrived and ineffective.[13]

DoD's concerns regarding the transition of technology to application are broader and much more fundamental than are those contained in technology transfer legislation and existing directives. In fact, the "tech transfer" concept embedded in the legislation continues an emphasis on "spin-off" to civilian applications, which is becoming less important, and less relevant to overall technology competitiveness. This concept presumes DoD's R&D enterprises are developing technologies that (1) lead the developments of the commercial sector, and (2) have commercial potential. These assumptions, perhaps true in the 1960s and 70s, are decreasingly valid today.

DoD can benefit by learning and adapting best commercial industrial practices in its own developments. In commercial industry, there have been major efforts to redefine the inter-relationships between product development and transition to production. In our view:

- DoD has a stake in domestic industry learning how to better transition R&D into applications. What programs should DoD foster to see this happen?
- DoD should formulate explicit programs to improve the transfer of technology **from** commercial industry **to** DoD developments and applications.

Congress has required the mission agencies to actively foster technology transfer. Our assessment is that it is in DoD's interest to define and develop a technology strategy that embraces two-way technology transfer, but places it within the broader need to integrate military technology developments into a common production capability that can expedite the application of technology to meet security needs.

6. DoD and a National Technology Strategy

For over forty years, DoD has played a key role in fostering technology development and has exercised this role effectively. However, with the radically changed threat environment, and the shift in the relative technological leadership of the U.S.—

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[13] This issue is discussed in detail by John A. Alic, Lewis M. Branscomb, Harvey Brook, Ashton B. Carter, and Gerald L. Epstein, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, Harvard Business School Press, Boston, MA, 1992.

particularly regarding the ability to effectively bring technology to fruition as new, competitive products—DoD must re-evaluate the basic premises it has used to foster technology development. In our view a key element of DoD's response to this new future is the need to formulate a cooperative strategy within the national government overall for those technology areas concerning an integrated defense and commercial base. DoD needs to emphasize that while it depends upon the nation's technology and industrial base, it cannot be unilaterally responsible for its health and well-being. Congress and the Executive branch must appreciate the limits of scope and effectiveness of DoD as it moves beyond its mission-specific role. DoD can be effective in selectively and judiciously supporting technology development beyond DoD's immediate charter. But, there are clear limits to its effectiveness and clear costs to DoD being asked to assume too large a role.

DoD has developed an S&T strategy focusing on subsystems and components, as opposed to systems. This strategy emphasizes important functional capabilities, such as surveillance, and precision strike, which take advantage of U.S. technological capabilities in applying electronics technologies. In addition, it stresses the application of these technologies to training and to producing and acquiring more affordable systems. These are important first steps. But beyond these there is a need to establish mechanisms and institutions to sustain R&D relevant to the broader national industrial base needed to develop and produce these technologies. DoD should support and establish linkages to programs in the rest of the federal government that attempt to realistically appraise overall technological capabilities, and that seek to support those technology developments that underpin productivity and innovation within U.S. industry.

DoD has taken on a role of stewardship for key technologies that were identified as intrinsically important to future national security needs. Today, as technology spreads rapidly throughout the world and as commercial applications often outstrip DoD's ability to employ technology, DoD must better integrate its technology programs with a broader national programs. From a national security perspective, a national technology strategy is necessary if DoD is to be effective in defining and meeting its needs. Without closer integration, the Department is buffeted in an incoherent, often contradictory mode of operation, being pulled by Congressional mandates one way and Executive dictates the other.

C. DESIGN, ENGINEERING, AND PRODUCTION IN THE NEW ERA

Rapidly transitioning industrial production to scale-up defense production to meet reconstitution demands will require integrated engineering teams experienced in designing, developing and producing large, complex systems, such as weapons systems. The development process includes a large investment in human capital, not only involving trained individuals with long experience, but also involving teams that take years to assemble. Such teams are expensive and difficult to assemble, but they are also difficult to hold together if they do not have serious work.

As defense procurement decreases, defense contractors will be forced to scale-back their engineering work force, and in particular will cut back in the production end of the spectrum. Given this prospect, the desire to see greater consideration of manufacturing concerns during design and development may well suffer, particularly if DoD places increasing emphasis on R&D without producing systems in quantity. DoD must pursue an R&D strategy in awareness of the need to link and integrate its development programs to production in a manner very different from that which is in effect today. The major differences will be (1) efficiencies obtained through scale of production and learning curve dynamics—in the past achieved through steady procurement over time—will have to be replaced by alternative mechanisms, likely drawing heavily upon computer simulation; and (2) the military-specific production facilities of defense contractors upon which DoD has relied in the past will have to be replaced by approaches permitting rapid access to commercial (civilian) production facilities. Both should have a profound effect on how DoD conducts its R&D.

With the reduction of defense systems procurement, it is not yet clear whether maintaining a core of design, development, and production engineering teams will be a problem and, if so, to what extent and in what areas. For example, in warfare areas such as tactical aircraft, where there are on-going development programs, the needed cadre of aircraft engineers will obviously be retained. But over time, if the current developments are not produced as "fieldable" systems, and if there are reduced efforts to design newer systems beyond those currently conceived, it is likely that these engineering teams will dissipate.

As the number of systems being developed shrinks, the engineering teams will shrink accordingly. Adequate attention will have to be paid to scaling up these teams and their capabilities to move next-generation developments into production when they are needed for reconstitution. In the tank area, where production is slated to be terminated,

teams of engineers may already be broken up. A review of such problem areas is needed to identify alternative mechanisms for retaining or reconstituting key development and design capabilities if they are necessary. For example, ATDs relating to ground combat may provide one mechanism for supporting core tank engineering teams.

Another concern is how to ensure that tanks designed through such ATDs can be moved into production. Special emphasis would be required in the design phase on integrating this production into manufacturing capabilities that will be available, perhaps heavy machinery, tractor, or truck production lines. The key is to design the system so as to use components, processes and facilities compatible with those used in commercial industry. A new way of thinking about the design-development-production relationship will be necessary, and the ATDs themselves can be used to test methods of going from development to production and of making weapons producible.

1. Engineering Tools and Methods

An important aspect of the development infrastructure consists of the tools and methods available for engineering the systems to be produced and for their production. Improvements in design and engineering tools need to be pursued to reduce the time needed to field the next generation of weapons. More importantly, these engineering tools need to be responsive to the changing production environment—the defense industry needs to use and be linked to the technology development and production planning and management tools that are available throughout industry. Moreover, the process of designing and developing defense-specific systems should be explicitly conducted to maximally integrate production into the civilian production stream. Special analytical tools are required to permit this.

Computer-aided design (CAD) and computer-aided engineering (CAE) tools can reduce the man-hours required to design and engineer a product. Coupled with computer-integrated manufacturing (CIM) and computer-aided manufacturing (CAM), the time required to transition from design to production can be cut substantially. But, from the standpoint of ramping-up defense forces to meet national emergencies requiring a scale-up of military production, techniques to flexibly integrate military production into on-going civilian production are essential. The combination of these new technologies should thus broaden the potential supplier base, allowing defense production to be supported by computer-operated machine tools throughout the economy. For example, as part of the subcontractor-supplied technical data package for the Patriot, Raytheon

required one of its subcontractors to provide an extra copy of the computer tapes used to drive the numerically controlled machine tools employed in making gyroscope components. Using these tapes, another supplier with similar machine tools could begin manufacturing these components very quickly. The extension of such technology could substantially increase DoD's flexibility to tap new suppliers when needed to support reconstitution. Thus, a major objective should be to develop approaches for making such tools affordable and accessible to small and mid-sized firms.

The tools described above should enable even greater use of "concurrent engineering" techniques (and similar new approaches to managing development programs) that can sharply reduce the time required to develop new systems. One aerospace manufacturer used concurrent engineering principles to reduce development time by 45 percent. Automobile manufacturers who employ "lean design" principles are able to design a new model in about three-fourths the time, using about two-thirds the engineering hours required for traditional design practices. If such approaches were adopted, the time required to transition next-generation weapons from the design stage through development and into production could be cut substantially. Clearly, this would significantly contribute to meeting reconstitution objectives.

2. The Flexible Factory

Defense integration also involves transforming how factory floor processes operate in order to produce components, subsystems, and even systems needed for defense on the production lines of manufacturers that can serve both commercial and defense customers. A prime contributor to high defense system cost is the low volume production of defense items in specialized production facilities that are expensive to operate and that have low yields. The goals of applying flexible manufacturing to defense include (1) the rapid fabrication of prototypes and the production of items in small lots for defense applications at unit costs approaching those of mass production; (2) the use of "programmable factories" driven by concurrent engineering concepts that have been optimized for zero-defects using "virtual factory" simulators; and (3) the integration of defense production with commercial production to achieve maximum return to scale during peacetime operation and rapid transformation when needed for scaled-up military production.

It is critically important for the DoD to stay up with and shift its production into the rapidly changing world of commercial industry. Industries worldwide, including key

segments of commercial U.S. industry, have increased their productivity dramatically due to the vast improvements in process automation, detailed application of statistical process control, and techniques of total quality management. Moreover, there has been a shift toward a rapid turn-around concept in which mass production concepts are being replaced by highly adaptable and flexible production. As lean production and agile manufacturing become key determinants of competitive industries, they also make much more feasible the production of defense items on commercial production lines.

However, the DoD process of acquisition and its overall R&D must be refocused toward these capabilities, if defense is to take full advantage of these prospects. The current procurement and the current methods for system design and development are not now attuned to these capabilities, and for the most part work against them.

3. Enterprise Integration

The ability to interrelate production control, inventory management, supplier-customer interface, and a host of other functions that are needed to support the design and manufacturing process, so as to optimize enterprise performance, is an area where major cost savings can be gained. The DoD production process, with its linkages among prime contractors, multiple subcontractors, and vast numbers of suppliers, offers the prospect of achieving greatly increased efficiencies through the use of information processing and analysis technologies. In addition, these techniques will be vital to the ability to rapidly focus the network of commercial-military vendors of the future on the required mix of products needed to meet scaled-up defense needs in times of emergency. Thus, enterprise integration is not only valuable for cost-reduction, but also will enable the effective transitioning of the national peacetime industry to one able to respond to heightened national security demands.

4. Improved Production Through Simulation

A key capability to facilitate the flexible manufacturing of defense components and systems in an integrated manufacturing environment is computer simulation. The ability to simulate products and manufacturing processes in the design phase will allow designers to create "virtual prototypes." In this environment, new designs could be analyzed on a computer-simulated virtual battlefield for the assessment of operational utility. Just as important, manufacturing issues could be examined in a parallel virtual factory, permitting assessment of producibility issues, including the ability to integrate

and scale-up production on non-military production systems. Also, reliability and logistics issues could be examined with product life-cycle engineering simulations. Many of the technical and manufacturing problems that presently plague acquisition programs in the engineering and manufacturing development phase may be eliminated by utilizing these methods, allowing next-generation weapons to be fielded far more quickly than is possible today.

Within the manufacturing environment, it will be necessary to experiment with new techniques and to be able to develop expertise in them quickly. Particularly if large-scale transformation of production systems from one set of products to another is anticipated, it will be necessary to be able to respond quickly with relatively little interruption. If systems are designed for such flexibility from the outset, then the transition difficulties should be lessened. However, it is also likely that it will be necessary to exercise the ability to convert toward defense production on some sort of systematic basis. Clearly, given that the DoD will have some fluctuating needs for military procurement over time, some of the network for responding to heightened demand must be tested periodically. It will be necessary to ensure that the overall concept and capability for rapid conversion is in place. This as one of the great potential values of "virtual" factory or enterprise simulation. Specifically, if factories and the linkages among enterprises are developed using computer modeling techniques, and these technologies can be used to update and evaluate production operations of individual enterprises and their inter-relationships, then the simulations can be exercised to investigate the "surge" capabilities as well.

Simulation models of enterprise flexibility and responsiveness also will have to be tested against actual performance. In our view, DoD will have to be prepared to actually acquire real products in a surge mode periodically to evaluate the ability of the new production paradigm to perform. Currently there are critical areas where our surge capabilities may be inadequate due to concentrated bottlenecks, foreign dependencies, out-of-production components, and materials shortfalls. Modeling the surge capabilities of the more robust commercial-defense industrial system will be useful and necessary. Particularly as DoD relies more and more on the commercial industrial base, it will be necessary to determine if there are specific foreign dependencies that create potential vulnerabilities, and to plan for alternative means for assuring supplies of such materials or components. The use of advanced simulation systems to design new, flexible production

facilities and to evaluate their efficiency over time should provide much greater capabilities to plan and prepare for the contingencies of reconstitution, when required.

D. CONCLUSIONS: ACHIEVING DEFENSE - COMMERCIAL INTEGRATION

In summary, the Defense Department's new science and technology program emphasizing technology demonstrations provides a sound technical basis for reconstituting forces with next-generation weapons. The proposed emphasis on manufacturing issues in the advanced technology demonstration programs improves the prospects for the technologies being more easily incorporated into weapons and more rapidly fielded than they are now. In addition, rapid advances are being made in design tools, process integration and control, and production management. These areas deserve continued emphasis as important elements of a reconstitution strategy. Efforts to achieve better integration of development and production could prove to be the most cost-effective investments available for improving reconstitution capabilities.

A robust technology base should continue to support specific technologies that have broad application, in particular those key or critical technologies that are seen as having great potential leverage. Also, research for advancing specific weapons technologies should continue, but this should be based on the projected requirements of the new threat environment and disciplined by two key constraints: the projected financial limits on future systems procurement and the need to explicitly link future production of such systems into the overall national production base. Future weapons R&D should be directly tied to the criteria defined at the beginning of this chapter—affordability and producibility.

There still is need for pursuing research into highly advanced new concepts for weapons, the type of research that went into stealth, stand-off weapons, and directed energy weapons. While the imperative to outflank the force build-up of the Soviet Union through major technology breakthroughs is gone, the prospect of new technologies permitting some potential adversary to achieve substantial advantage by introducing a radical weapons concept needs to be guarded against. This said, such exploration of radical weapons concepts clearly should be of a reduced scale and scope relative to those pursued during the height of the Cold War.

Where greater emphasis needs to be directed is toward explicit consideration of the linkage of DoD's R&D strategy to the broader technological capabilities of the

country and the economic and industrial base that are needed for it to succeed. We see this as placing priority on

(1) Explicit incorporation of commercial components into ATDs, prototypes, and weapons modification programs, and stressing the use of commercial production in components and subsystems development programs;

(2) Experimentation with new approaches for designing, developing, and producing weapons components and subsystems that maximally employ and or integrate with commercial approaches and facilities;

(3) Research and development that emphasizes dual-use in preference to militarily-specific components and subsystems;

(4) Research and development of production processes that increase production flexibility, rapid product introduction and change-over, and integration across military-commercial production; and

(5) Greater integration of defense systems and process R&D with those of non-defense agencies and with greater attention to those of commercial industry.

CHAPTER V. RECOMMENDATIONS

To meet the strategic goal of reconstitution we recommend a reshaping of weapons systems acquisition focusing on the following three elements:

[1] Base force programs scaled to meet crisis contingencies, that is modernized progressively through systems upgrades and replacement, and that maximally integrates support and training with resources in the civil economy;

[2] Fundamental revamping Defense acquisition to maximally achieve industrial base integration—reforming internal DoD processes and DoD's relationships with contractors so as to promote integration by minimizing the distinction between defense and non-defense contractors and the distinction between defense products and other products; and

[3] Refocusing Defense science and technology programs emphasizing affordability, producibility, rapid transition into application, and integration with the commercial production.

Accomplishing these measures for reshaping defense acquisition will require acceptance of ways of thinking and doing business that are fundamentally different from those practiced over the past forty years. DoD must give these institutional focus and priority within its operational, acquisition, and R&D communities. Nothing less is needed than a major re-orientation of how Defense thinks about what and how it develops and produces.

A. DEVELOP BASE FORCE FOR FLEXIBILITY AND RECONSTITUTION

- **Design Base Force To Facilitate Expansion To Reconstituted Force**

As the first step in achieving a capability for reconstitution DoD must develop a base force which incorporates into its systems inherent flexibility for expansion and takes advantage of the manpower, goods and services in the civilian economy to build up its forces. The force itself should include only those capabilities and skills needed for crisis contingencies. To this end DoD should plan and prepare for reconstitution to draw primarily on the skills and facilities of the commercial sector.

As two key elements providing for flexibility in expanding the base force DoD should give special attention to training and standby commercial activities:

- **Training** -- Expand the use of technology for training, including computer learning and simulation, to enable the DoD to reduce both the time and personnel resources required for training. Design next-generation weapons and support systems to make them easier to operate, allowing soldiers to become quickly proficient in their use.
- **Expanded use of Standby Commercial Services for Support Functions** -- In planning for support functions take maximum advantage of the manpower, goods and services in the commercial economy to build up crisis response and reconstitution capabilities, generally through standby contracts to provide commercial services which are the same as services needed in DoD. These could include telecommunications, logistics, engineering, electronics maintenance medical support, food processing, catering, laundry, automotive and aircraft maintenance and repair and express delivery of spare parts and other supplies, and construction.

- **Re-Orient Weapons System Requirements Process To Emphasize Producibility and Reconstitution**

In defining systems requirements DoD should give much greater consideration to cost, producibility, and efficiency of future production (surge and reconstitution). Reconstitution places an imperative on being able to engage the industrial production capabilities of the economy as a whole efficiently. A primary consideration for designing next generation systems should be, "Can we build them when we need them?"—refocusing the weapons systems development process on the ability to efficiently and effectively use the nation's future commercial industrial capability.

B. REVAMP DEFENSE ACQUISITION TO ACHIEVE DEFENSE AND COMMERCIAL INDUSTRIAL BASE INTEGRATION

- **Tailor DoD's Rules and Regulations Based On Degree Of Technological Uncertainty Of The Product and The Nature Of The Market**

All regulation should be examined by type of product to find the minimum needed to protect the interest of the Government. Reduce regulations by tailoring them to the nature of the market and product; less regulation is needed as the market becomes more competitive and as the products become more predictable (less specialized and experimental).

- **Eliminate, To The Extent Possible, Distinction Between DoD Contractors and Other Firms Conducting Interstate Commerce**

Regulation involving broader societal goals should be imposed on DoD contractors in the same manner as they are on other firms engaged in interstate commerce. Defense firms are already required to obey the laws and pursue programs involving social, environmental and workplace goals, as firms engaged in interstate commerce. Thus, they should not have to set up separate systems to adhere to different laws involving discrimination, health and safety and other areas.

- **Reduce The Use Of Military Specifications and Products**

Increase the availability of suppliers and products to DoD by moving from specialized military standards to commercial or and non-government standards wherever possible. Where standards are overly restrictive, accept commercial products. When specialized products are needed move to performance or form, fit and function measures.

- **Introduce Commercial Buying Practices Into The DoD Procurement System**

Eliminate the "right" of any potentially qualified bidder to bid on contracts and remove the obligation of the DoD or Government purchasing agent to assure that all such potentially qualified bidders are aware of the interest of the DoD in the purchase. This is a right which has no analogy in the private sector.

- **Minimize Separate Cost Accounting and Other Reporting Systems**

Contractor performance should be judged as much as possible on the price and quality of the product rather than on the ability of the contractor to satisfy DoD-specialized accounting and auditing requirements. Market analysis, combined where appropriate with statistical cost analysis, should be used in place of "cost accounting standards."

- **Eliminate Special DoD or USG "How To Manage" Requirements**

DoD and the Federal Government should eliminate "How To Manage" Standards, e.g., Systems Engineering Management, that have little to do with the functionality of the product or even its specifications, but rather are attempts to monitor the management techniques of government contractors. Such standards increase the burden on the

contractor and hence the cost to the Government without a commensurate increase in the value of the product.

- **Allow Contractors To Retain Technical Data Rights—**

Restrict DoD's ownership interests in technical data to those necessary for defense purposes; data rights should remain with the contractor to encourage commercial development and encourage commercial firms to conduct business with DoD.

- **Rationalize Information Protection Policies Including Export Controls**

Information protection, especially export controls, should be rationalized to those appropriate to the new security environment.

C. RE-FOCUS DEFENSE RESEARCH AND DEVELOPMENT TOWARD INTEGRATED TECHNOLOGY AND INDUSTRIAL BASE

Greater emphasis needs to be directed toward explicit linkage of DoD's R&D strategy to the broader technological capabilities and industrial base needed for a reconstitution strategy.

- **Change criteria for Defense R&D to:**

Affordable Performance. Use technology to leverage performance relative to system acquisition and ownership costs.

Employment of commercial technologies and practices in defense applications. emphasize the use of advanced commercial technologies and processes in military applications.

Flexibility and integration of production. Design of weapons should incorporate their rapid transition into production; create flexible development and production systems, integrated with the commercial product development and production facilities of the country.

Viability of dual-use product and process technologies. Increase support for advances in "dual-use" technologies, especially the processes for more flexible production of dual use technologies.

- **Focus Defense S&T Programs on Responsiveness, Flexibility, Affordability**

Given uncertainty of where future threats to U.S. security will arise, DoD should emphasize technology for achieving very rapid but effective responses to threat situations and to make effective defense more flexible and less costly.

- **Conduct Advanced Technology Demonstrations (ATDs) for Production Integration**

ATDs should be used to assess and demonstrate the ability to manufacture defense systems in commercial production facilities by adapting the military system to commercial production. Such ATDs should also be used to test the design of a flexible factory, and to feedback to simulations of production systems. These should emphasize the use of commercial components and subsystems to the maximum extent.

- **Emphasize R&D To Improve The Integration of Defense Production With That Of The Civil Sector**

DoD should give priority to research and development for improving the efficiency of Defense production—manufacturing—*in concert* with U.S. industry overall. To achieve this DoD should specifically support dual-use developments in

  - Engineering tools and methods such as CAD and CIM
  - Flexible factories—particularly those allowing simultaneous defense commercial production
  - Enterprise integration—to reduce overhead and promote lean production
  - Training and planning through simulation—"virtual" factories

- **Focus R&D Efforts On Applying Advanced Commercial Technology To Defense Systems**

DoD should support commercial industry's ability to transition technology to practice and DoD should implement programs to learn and adapt commercial industrial practices in its own developments. DoD should formulate explicit programs to improve transfer of technology from commercial industry to DoD developments and applications.

- **Integrate/Coordinate Defense and Civilian R&D By Linking DoD Technology Development To A National Technology Strategy**

DoD should seek the integration of its technology development into a broader national technology strategy to ensure that the technologies developed by DoD can be produced efficiently within the overall U.S. economic capabilities with minimal specialized defense production facilities or capabilities. DoD should work to formulate a cooperative strategy within the overall national government to achieve an integrated defense and commercial base.